NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

A STATISTICAL ANALYSIS DETERMINING EFFECTIVE AND EFFICIENT METHODS OF SHIPBOARD TRAINING

by

Kirk A. Michealson

March 1987

Thesis Advisor D.E. Neil

Approved for public release; distribution is unlimited.

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION: UNCLASSIFIED

1b RESTRICTIVE MARKINGS:

2a SECURITY CLASSIFICATION AUTHORITY:

2b DECLASSIFICATION / DOWNGRADING SCHEDULE:

3 DISTRIBUTION / AVAILABILITY OF REPORT: Approved for public release; distribution is unlimited

4 PERFORMING ORGANIZATION REPORT NUMBER(S):

5 MONITORING ORGANIZATION REPORT NUMBER(S):

6a NAME OF PERFORMING ORGANIZATION: Naval Postgraduate School

6b OFFICE SYMBOL (If applicable): 55

7a NAME OF MONITORING ORGANIZATION: Naval Postgraduate School

6c ADDRESS (City, State, and ZIP Code): Monterey, California 93943-5000

7b ADDRESS (City, State, and ZIP Code): Montery, California 93943-5000

8a NAME OF FUNDING / SPONSORING ORGANIZATION:

8b OFFICE SYMBOL (If applicable):

9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER:

8c ADDRESS (City, State, and ZIP Code):

10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO	PROJECT NO	TASK NO	WORK UNIT ACCESSION NO

11 TITLE (Include Security Classification): A STATISTICAL ANALYSIS DETERMINING EFFECTIVE AND EFFICIENT METHODS OF SHIPBOARD TRAINING

12 PERSONAL AUTHOR(S): Michealson, Kirk A.

13a TYPE OF REPORT: Master's Thesis

13b TIME COVERED: FROM ______ TO ______

14 DATE OF REPORT (Year, Month, Day): 1987 March

15 PAGE COUNT: 116

16 SUPPLEMENTARY NOTATION:

17 COSATI CODES

FIELD	GROUP	SUB-GROUP

18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number): Comparison of Training Methods, Training Effectiveness, Training Efficiency, Lectures,

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

A significant factor affecting the operational readiness of the surface Navy is the training of personnel to operate and maintain shipboard systems and equipment. Even though the importance of training is not disputed, factors such as effectiveness and efficiency must still be considered before selecting a specific method of instructional delivery. This study compared the most common training methods in the surface Navy using one-way analysis of variance (ANOVA), individual degree of freedom ANOVA, and two sample testing techniques to determine which methods were the most effective and efficient. The methods compared were live lectures, video presentations, silent reading, and audio presentations at three different speeds. The analyses showed that audio presentations at normal speed and at 1.25 times normal speed were the most effective and efficient, while the two most common methods of

20 DISTRIBUTION / AVAILABILITY OF ABSTRACT: ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS

21 ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED

22a NAME OF RESPONSIBLE INDIVIDUAL: Doug E. Neil

22b TELEPHONE (Include Area Code): (408)646-2419

22c OFFICE SYMBOL: 55NI

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

18. SUBJECT TERMS (continued)
Silent Reading, Video Presentations, Audio Presentations, and Firefighting.

19. ABSTRACT (continued)

instructional delivery (live lectures and video presentations) were significantly less effective in the majority of the comparisons.

A Statistical Analysis Determining Effective and Efficient Methods of Shipboard Training

by

Kirk A. Michealson
Lieutenant, United States Navy
B.S., United States Naval Academy, 1979

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
March 1987

ABSTRACT

A significant factor affecting the operational readiness of the surface Navy is the training of personnel to operate and maintain shipboard systems and equipment. Even though the importance of training is not disputed, factors such as effectiveness and efficiency must still be considered before selecting a specific method of instructional delivery. This study compared the most common training methods in the surface Navy using one-way analysis of variance (ANOVA), individual degree of freedom ANOVA, and two sample testing techniques to determine which methods were the most effective and efficient. The methods compared were live lectures, video presentations, silent reading, and audio presentations at three different speeds. The analyses showed that audio presentations at normal speed and at 1.25 times normal speed were the most effective and efficient, while the two most common methods of instructional delivery (live lectures and video presentations) were significantly less effective in the majority of the comparisons.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

TABLE OF SYMBOLS

SYMBOL	DEFINITION
α	Alpha level; level of significance
α_R	Critical level
H_0	Null hypothesis
H_1	Alternate hypothesis
μ_A	Population mean of the test scores from method A
σ_A^2	Population variance of the test scores from method A

TABLE OF ABBREVIATIONS

ABBREVIATION	MEANING
ALL	All Seventy Test Scores
ANOVA	Analysis of Variance
BE & E	Basic Electricity and Electronics
CNETINST	Chief of Naval Education and Training Instruction
CRTLVL	Critical Level
DCA	Damage Control Assistant
DF	Degrees of Freedom
ESWS	Enlisted Surface Warfare Specialist
EQUAL	Groups of Equal Size
FSTAT	Test Statistic for the F-test
GPA	Grade Point Average
HT	Hull Technician
i.e.	That is
MS	Mean Square
NTC	Naval Training Center
NTSC	Naval Training Systems Center
OPNAVINST	Naval Operating Instruction
PQS	Personnel Qualification Standards
RGL	Reading Grade Level
RTC	Recruit Training Command
SS	Sum of Squares
SSC	Service School Command
STD DEV	Standard Deviation
U.S.	United States
WPM	Words Per Minute

ACKNOWLEDGEMENTS

I gratefully acknowledge the following personnel from the Naval Training Center, Orlando, Florida, for their support and discussions while performing the experiment: LCDR Wright, EMCM McLaughlin, TMCM Arendts, TMCM Loechner, and Senior Chief Hewitt from the Basic Electricity and Electronics School; HTCM Hannan and AQCS Plocar from the Recruit Training Command; and Dr. Bob Evans, Dr. Dennis Wightman, Dr. Bob Ahlers, Dr. Cheryl Hamel, and Dr. Jim Driskell from the Human Factors Division of the Naval Training Systems Center. Special thanks go to LCDR Mike Lilienthal for his guidance and support. Additionally, in Pensacola, Florida, Dr. Carl William's support was greatly appreciated.

At the Naval Postgraduate School, thanks go to CDR Charles Hutchins, LCDR Mark Mitchell, LCDR Chris Schnedar, and Professor Glenn Lindsay for their ideas and encouragement, and especially Professor Doug Neil for providing source materials, ideas and encouragement.

Finally, to my wife, Sherrill, go my deepest thanks for her patience, her understanding, and her support.

I. INTRODUCTION

A significant factor affecting the operational readiness of the surface Navy is the training of personnel to operate and maintain shipboard systems and equipment; because of this, the training of personnel is essential. Nevertheless, training programs cannot be blindly initiated without due consideration of the cost of the program, the amount of productivity lost, and the amount of knowledge gained. For example, a senior Hull Technician (HT) has responsibilities in many areas which require him to attend numerous training lectures either as a lecturer or as a trainee (Table 1). In fact, the HT can spend over twenty percent of his workday involved in training. Therefore, in order to maximize the amount of work completed, training programs aboard ship must be efficient as well as effective.

TABLE 1

WEEKLY TRAINING FOR HULL TECHNICIANS

TYPE OF TRAINING	NUMBER OF LECTURES	LENGTH OF EACH LECTURE
Damage Control Petty Officer	2	1 hour
General Damage Control	3	.5 hour
Fire Marshall	1	.5 hour
Gas Free Engineer	1	.5 hour
Hull Technician	2	.5 hour
Sounding and Security Watch	1	.5 hour
Damage Control Central Watch	1	.5 hour
Team Training		
-Inport Fire Drill	2	.5 hour
-Inport Fire Party	2	.5 hour
-At Sea Fire Party	1	.5 hour
-Helicopter Firefighting	1	.5 hour
-Accident and Incident	1	.5 hour

An explanation of the factors used in determining the effectiveness and efficiency of a training program is as follows: the preparation cost includes the man-hour investment, the development of repeatable programs (with and without instructors), and the length of the lecture; while the material cost is the cost of the training equipment [Ref. 1: pp. 70-74]. The amount of productivity lost is a function of whether training is held during working hours and how long the training session lasts. Finally, to determine the amount of knowledge gained, the test results of a group that has completed training are compared with the test results prior to training.

Currently the common methods of instructional delivery used in the surface Navy are lectures given by subject matter experts, lectures on videotape, and silent reading. Audio presentations are used to a limited extent. Research indicates that each of these methods have strengths and weaknesses [Refs. 1,2,3,4], but what the research literature does not show are comparisons of training effectiveness among the methods. Therefore, the intent of this study was to determine which methods of instructional delivery are the most effective and efficient by contrasting the preparation and material costs and the amounts of productivity lost and knowledge gained in each method.

The format of this paper is as follows: Chapter II summarizes the results of past research done on the individual methods, Chapter III describes the initial experimental design of this study, and Chapter IV contains the procedures used to compare the common methods of instructional delivery in the surface Navy. The results of the experimental data's statistical analyses are in Chapter V, while this study's recommendations are presented in Chapter VI.

II. BACKGROUND

A literature review suggests that most research efforts have been directed at individual training methods' strengths and weaknesses [Refs. 1,2,3,4]. Only one study was found which compared the effectiveness of various presentation methods [Ref. 5]. This chapter will summarize the results of past research on four individual methods (live lectures, video presentations, silent reading, and audio presentations) and on the one study which compared the various training methods.

A. LECTURES

Lectures are presentations of course content by an instructor to a group of trainees who remain passive during the period of instruction. Lectures may be in the form of live, video, or audio presentations and are often the most cost effective type of training. The preparation time is only two to eight man-hours per hour of instruction and the instructors' skill level does not need to be high in comparison to other training approaches. Frequently, a problem with using lectures is the lack of observable trainee response during the presentation. Also, in view of the fact that the transfer of learned behavior from the lecture to the job situation is frequently difficult, it is better to use hands-on training to accomplish this objective. [Ref. 1: pp. 71-74]

B. VIDEO

Training by television (i.e., a video presentation) is an effective method of instructional delivery that yields high knowledge retention levels in the trainees and is generally preferred to conventional classroom instruction [Ref. 2: p. 23]. The only possible drawback would be the material cost when a video system is not already available.

C. READING

Reading is a process of comprehending language through print, regardless of the volume of material considered. The accuracy of comprehension is affected by the purpose for which one reads, whether for enjoyment or learning, and comprehension decreases in a roughly linear fashion with increasing reading rates. The norm reading rate is 185-300 words per minute (wpm). [Ref. 3]

The readability of an article refers to the ease or difficulty of reading the material, and the readability level is the equivalent grade level of the article. In order to achieve high comprehension levels, the readability level should be equivalent to the reading ability of the trainees. [Ref. 4: pp. 3-4]

D. AUDIO

Auding is defined as the process of listening to speech to understand the thoughts presented by the speaker. Compressed speech is recorded speech which is presented in less than its original time by using a variable speed, pitch control tape recorder. In the many studies comparing comprehension level with the rate of auding, a rapid decline in comprehension was noted when the delivery exceeded 275 wpm, regardless of the percent compression used to achieve that word rate. As a comparison, the norm auding rate in everyday situations is 125-200 wpm. [Ref. 3]

Other conclusions reached in the studies on audio presentations were: (1) trainees were noticeably less fatigued [Ref. 6: p. 17], (2) the higher the auding rate, the more the trainees concentrated [Ref. 7], (3) comprehension improved or remained constant from 125 to 275 wpm [Ref. 8], (4) retention followed the same patterns as it did for listening normally or reading [Ref. 8], (5) trainees expressed favorable attitudes [Ref. 9], and (6) some poor readers preferred to learn by listening rather than by reading [Ref. 10].

E. COMPARISON OF TRAINING METHODS

During a class project in a Human Factors course at the Naval Postgraduate School, the experimenter contrasted three methods of instructional delivery using an experimental group and a control group [Ref. 5]. The project was designed to compare the comprehension levels of the groups in two different ways: (1) by reducing the amount of time alloted for reading or listening to the training material, and (2) by reinforcing the material in the video presentation with visual aids. The results indicated that higher comprehension levels were obtained when using visual aids in video presentations and when the speed of the audio presentations was increased. However, the authors indicated that significant problems were encountered while performing the experiment and recommended that these problems be corrected before any further studies were conducted. The problems they experienced during the experiment were:

- the control group was not maintained,
- the sample was not selected randomly,

- the lengths of the training session varied significantly, and
- guesswork type of questions were used.

By using this class project [Ref. 5] as a pilot study, a detailed initial design was developed to prevent the occurrence of these above mentioned problems while comparing various methods of instructional delivery. This initial experimental design is presented in the following chapter.

III. INITIAL EXPERIMENTAL DESIGN

This chapter discusses the initial experimental design. The design was developed in preparation for performing the experiment at the Naval Training Center (NTC) in Orlando, Florida. Setting up the initial design included deciding which training methods would be compared, choosing a random sample of students, administering the experiment, selecting the appropriate topic for training, writing the training document, and ascertaining suitable background information on trainees. A discussion of these subjects follows.

A. SHIPBOARD TRAINING METHODS

The shipboard training methods utilized most frequently are live lectures, video presentations, and silent reading. To a limited extent, audio presentations are also used for training. Therefore in this experiment, nine different methods of instructional delivery were to be compared (see Table 2). Live lectures and video presentations were to be contrasted using the presence of visual aids as the source of variation, while the variation in the audio presentations and the silent readings was time. In order to determine if any knowledge was gained by attending these training lectures, the students in the control group were to be tested to establish the current knowledge level of the trainees.

TABLE 2

SHIPBOARD TRAINING METHODS TO BE COMPARED

METHOD	VARIATION
Live lecture	with visual aids
Live lecture	without visual aids
Video presentation	with visual aids
Video presentation	without visual aids
Audio presentation	norm auding rate
Audio presentations	33% compression
Silent reading	norm reading rate
Silent reading	33% less time
Control group	no training given

B. CHOOSING A RANDOM SAMPLE

The students in the nine training method groups were to be chosen randomly with approximately twelve members per group. Although not carried out (see Chapter IV - section C), the initial plan was to contact all commands at the Naval Training Center requesting lists of assigned personnel. These lists were to be numbered and a sample of 150 names selected using a random number generator. Since training effectiveness depends on such factors as morale and enthusiasm [Ref. 11: p. 183], extra names were selected to give an individual the option of not participating in the experiment (i.e., to increase the chances of having all volunteers in each group). It was believed that a volunteer's morale and enthusiasm would be at a higher level than an individual who was required to attend training.

C. ADMINISTERING THE EXPERIMENT

Each of the eight training sessions (no training would be given to the control group) was planned to last approximately thirty to forty-five minutes. An additional fifteen minutes would be allowed to answer fifty questions testing comprehension, and approximately one week later, the students would have another fifteen minutes to take a second exam measuring retention. To reduce the possibility of guessing, both tests were to be written using fill in the blanks and short answer essays instead of multiple choice and true/false questions.

To maintain consistency between the groups, all of the presentations were to have the same instructor and were to be administered during the same time of day without a question and answer period at the end. The same instructor was necessary to ensure that each session was presented similarly, no matter which method of instructional delivery was used. The time of day that the training was given was important because crew attitudes and productivity were affected: if it was held during working hours, attitudes were usually positive but some productivity was lost, while if it was held after working hours, production time would be preserved but trainee attitudes were often negative. More importantly, training performance after working hours was not as satisfactory as performance in the same programs held during working hours [Ref. 1: p. 103]. However, since the experimenter had no control over the NTC Orlando commands, all training sessions had to be scheduled after working hours.

The purpose of not having a question and answer period was to prevent a possible bias on the exam for the group asking the question. For instance, if a question was asked and answered after the live lecture with visual aids, that group would have a better chance of correctly answering that particular part of the exam since they had been instructed on that particular material more than the other groups.

D. SELECTING THE APPROPRIATE TRAINING MATERIAL

Due to the anticipated diverse ratings of the randomly selected personnel, the topic chosen for training should not be specific to a few rates, but should be more general, as in an all hands type of training. General Damage Control - Firefighting is a type of shipboard training required to be completed by all hands within their first six months onboard and was the subject matter chosen for this study. A problem that needed to be considered when firefighting was chosen as the subject of training was the varying levels of damage control knowledge among personnel aboard ship. It was believed, though, that the sample would closely represent these varied levels due to the randomly selected individuals coming from different rates, different paygrades, and different warfare communities.

E. WRITING THE TRAINING DOCUMENT

The readability of the material must be considered when a training document is written. For instance, if a trainee encounters material far beyond or even slightly beyond his present reading ability, he may become discouraged and consider himself a failure, but if he can read the material and comprehend it easily, he will experience a sense of accomplishment [Ref. 12: pp. 2-3].

Readability research has been conducted involving many affective elements such as vocabulary, sentence length, sentence structure, and linguistic factors. Three of the more common methods of determining readability are the Dale-Chall Formula, the Fry Readability Graph, and the Gunning Fog Index. Of these, The Dale-Chall method is considered the most accurate. The Dale-Chall technique also has the most consistently comparable results in terms of both correlational and grade placement data, and has more of the high intercorrelations with other readability techniques. [Ref. 4: pp. 31,36]

These readability formulas were originally designed to test the material after it was written. Now they are also used during the writing phase. When using the readability methods in this manner, there is a possibility of misunderstanding the original content of the article [Ref. 13: p. 95]. This type of problem occurs when text

revisions are made to achieve a specific equivalent grade level. Therefore, before this study's training document can be used, it must be reviewed for its accuracy and its overall content.

All three readability techniques mentioned previously were planned to be used to compute the equivalent grade level of this study's firefighting training document. The procedures for using these methods are contained in Appendix H, "Readability Analyses."

F. ASCERTAINING SUITABLE BACKGROUND INFORMATION

At the initial training session, each student was to fill out a background questionnaire. The information obtained here was to be used to determine if there were any outliers in the sample. Outliers are "very small or very large values which are so far removed from the mainbody of the data that the appropriateness of including them in the sample is questionable." [Ref. 14: p. 33]

Other suitable information for this type of study were the high school grade point average (GPA), the amount of civilian schooling received, the Personnel Qualification Standards (PQS) completed or in progress, the last time the trainee was in school, the types of jobs held, and the amount of sleep received. The complete background questionnaire is contained in Appendix D.

After some revisions were made to this initial design, the experiment was conducted at the NTC in Orlando, Florida. The details of the procedures used to perform this experiment are contained in the next chapter.

IV. EXPERIMENTAL PROCEDURES

This experiment was conducted at the Naval Training Center in Orlando, Florida, from 12 May to 13 June 1986. Major changes in the initial design occurred in the following areas:

- the methods of instructional delivery to be compared,
- the sample selection, and
- the time of day training was held.

In addition to these changes, the following topics are also discussed in this chapter: the writing of the training document, the administering of the training session, the additional background information, and the variability of the results.

A. SHIPBOARD TRAINING METHODS COMPARED

In the initial design, the intent was to compare live lectures and video presentations to determine what effect the presence of visual aids had on comprehension, while the audio presentations and the silent readings were to be compared using time as the factor of variability (Table 2). Since the purpose of this study was to determine which methods of instructional delivery were the most effective and efficient, the nine training methods initially planned were changed to the seven methods shown in Table 3. Also, all of the seven training methods (except the control group) used visual aids in their presentations.

TABLE 3

SHIPBOARD TRAINING METHODS COMPARED

GROUP	METHOD	SPEED VARIATION
1	Live lecture	normal
2	Video presentation	normal
3	Silent reading	normal
4	Control group	no training given
5	Audio presentation	1.0 x normal
6	Audio presentation	1.25 x normal ---4/5 total time
7	Audio presentation	1.5 x normal ---2/3 total time

B. WRITING THE TRAINING MATERIAL

1. Development

The training material, "General Damage Control - Firefighting" (Appendix A), and the two case studies and answer keys (Appendix B) were developed utilizing the shipboard General Damage Control Personnel Qualification Standards as a basis. The PQS sections referenced covered Alpha, Bravo, Charlie, and Delta fires, and the training document was written by combining the corresponding sections contained in the *Hull Maintenance Tech 3 & 2* manual and several Damage Control Yellow Books [Refs. 15,16,17,18,19,20,21,22,23]. Additionally, subject matter experts were used to write the material and to review it for its authenticity: a surface ship Damage Control Assistant wrote it, and the division officer of the Recruit Training Command (RTC) Damage Control School, Orlando, Florida, reviewed the material.

2. Length

As initially designed, the plan was for the training session to last between thirty and forty-five minutes. Since the majority of the methods of instructional delivery compared were lectures, Reference 3's norm auding rate of 125 wpm was used as a guideline in the initial development phase. Thus, using this word rate, the goal for the length of the article was between 3750 words (thirty minutes) and 5625 words (forty-five minutes).

After an initial writing with approximately 12,000 words and several revisions that followed, the final length of the training document was 5630 words. This length led to actual session times (in minutes and seconds) shown in Table 4. The thirty five minutes alloted for the reading session led to a 161 word per minute reading rate which was below the norm range of 185-300 wpm [Ref. 3: p. 14]. This lower rate allowed the student to have more time reading the material than the norm reading rate would of allowed.

3. Readability

As stated previously, The training document had to be written in a manner that was easily understood. According to Reference 24, many sailors lack the reading skills necessary to cope successfully with school reading materials. In fact, the Chief of Naval Operations has stated that "a substantial proportion of recruits read below the tenth grade level." [Ref. 24: p. 3] This statement is verified in the statistics for the 6,698 recruits entering the U.S. Navy in March 1986: 32.44% read below the tenth grade level with an overall average reading grade level (RGL) of 9.7 [Ref. 25].

TABLE 4

TRAINING SESSION TIMES

GROUP	TRAINING METHOD	TIME
1	Live lecture	38:15
2	Video presentation	42:00
3	Silent reading	35:00
4	Control group	-------
5	Audio 1.00	33:15
6	Audio 1.25	26:15
7	Audio 1.50	22:00

OPNAVINST 1510.11 established a ninth grade reading ability as the minimum competency level for enlisted personnel. All recruits reading below this level (as measured by the Gate-MacGinitie Reading Tests) are given remedial instruction [Ref. 26: p. 10]. The March 1986 Recruit RGL Statistics showed that 22.93% read below this ninth grade level, and hence, received remedial instruction.

With these facts in mind, the Dale-Chall Formula, the Fry Readability Graph, and the Gunning Fog Index were used to write the training document on or below the ninth grade level. As required by each of these methods and due to the article's length, twelve 100-word samples were randomly chosen. The overall readability level was then computed by averaging the twelve samples' readability levels. Table 5 lists the initial results obtained by using the procedures described in Appendix E. As seen by the data in this table, all results were comparable with the Dale-Chall method. Therefore, all additional readability level computations were made using the Dale-Chall Formula.

TABLE 5

INITIAL READABILITY LEVELS

TECHNIQUE	EQUIVALENT GRADE LEVEL
Dale-Chall Formula	11-12
Fry Readability Graph	13
Gunning Fog Index	12-13

The first revision resulted in a 9-10 equivalent grade level with many words of the document still not on the Dale-Chall list of 3000 common words [Ref. 27: pp.45-54]. Many of these uncommon words were technical words or Navy words and acronyms (i.e., AFFF, underway, valve, missile, and equipment) which have no substitutes. Therefore, as recommended by Reference 24, a supplemental list or

glossary was constructed (Appendix C). A final equivalent grade level of 7-8 was achieved when the glossary was used, and in March 1986, only 6.78% of all recruits entering the Navy read below the seventh grade level [Ref. 25].

C. SELECTION OF THE REPRESENTATIVE SAMPLE

Instead of contacting the major commands at the Naval Training Center in Orlando as planned, previously established rules and regulations had to be followed. In accordance with CNETINST 3920.1F of 3 April 1986, a request for use of trainees to provide research data was initiated. Permission was granted to use seventy Basic Electricity and Electronic (BE&E) students from the Service School Command in Orlando, Florida. Most of the seventy trainees volunteered for this experiment while the rest were selected at random by the school.

A benefit gained by using this sample was a reduction in the overall variability of the experiment. Since the only firefighting instruction the trainees received was given at RTC, none of the test scores should be biased because of a student's background: they all received eight hours of classroom instruction and three hours of hands-on training. The only difference among the students was the amount of time since they had the training (although not recorded, it fell somewhere between six weeks and six months). Therefore, since all enlisted personnel receive the same amount of instruction at Recruit Training Command and the individual's damage control background level was not a factor of variability, the results of this study can be applied to all enlisted personnel in the Navy.

D. THE TRAINING SESSION

To maintain consistency between the groups, each training session was conducted in the same room by the same instructor (a subject matter expert). Permission was also granted to conduct all of the training sessions during the workday (instead of after working hours as originally planned), and hence, each trainee should have had a positive attitude.

Before any training began, the following two points were explained:

1. To prevent a possible bias on the exam, questions were not allowed to be asked during the sessions.
2. Notes could be taken for study purposes, but they could not be used during any exam.

During the training sessions, the same document used by Group 3 (the silent reading group) was also used by the instructor for the live, video, and audio

presentations. Overhead slides were substituted for the figures contained in the article. Immediately following these sessions, the trainees were given twenty-five minutes to take a fifty point test measuring comprehension, and about a week later, each student had thirty five minutes to answer a fifty point retention test. The first half of the retention test consisted of questions similar to those asked on the initial test ("old" questions), while the second half dealt with topics discussed in the lecture but not asked for on the initial test ("new" questions). Both tests were written as case studies requiring short essays for answers.

E. ADDITIONAL BACKGROUND INFORMATION

In addition to completing a background questionnaire during the initial session, the following questions were asked at the retention session:

1. How much sleep did you get last night?
2. How much studying did you do
   a. with your notes from last week's training session?
   b. with your notes from Recruit Training Command?
   c. in group study?

Again, these questions were asked for use in checking for outliers, and additionally, to determine if studying influences the trainees' results on the retention test.

F. VARIABILITY OF THE RESULTS

The differences in test results should be attributable only to the method of instructional delivery used because the following items were controlled:

- The same training document was used throughout the experiment.
- A low readability level was achieved.
- Visual aids were used in all training sessions.
- All trainees had previously received the same amount of instruction in firefighting.
- The training sessions were given in the same room.
- The training sessions were given by the same instructor.
- All of the training sessions were given during the work day.
- Questions were not allowed to be asked during the training session.
- Case studies were used instead of tests with guesswork type of questions.
- Time limits were imposed for taking tests.

The results of comparing the training methods for effectiveness and efficiency and the conclusions which can be drawn from these results are discussed in the next chapter.

V. RESULTS

The results from the initial test, the retention test, the old questions, and the new questions were compared using one-way analysis of variance (ANOVA), individual degree of freedom ANOVA, and two-sample tests. In addition to the above analyses, a discussion of the following items is presented in this chapter: the input data, the critical level, the data analysis approach, the goodness of fit results, an analysis of background information, and an analysis of the effects due to studying. Finally, the conclusions reached in this study are given at the end of this chapter.

A. INPUT DATA

Another precaution taken to reduce the variability of the results was to use the same person to grade all of the exams. One of the previously mentioned subject matter experts, the Damage Control Assistant, graded the initial and retention tests. These test scores were used as input data in this experiment and are listed in Appendix F, "Input Data."

B. THE CRITICAL LEVEL

In hypothesis testing, a Type I Error is defined as rejecting the null hypothesis (H_0) when the null hypothesis is true. The probability of committing this type of error is the test's α level or level of significance, and this level of significance defines the probability level that is considered too low to warrant support of the hypothesis being tested. For example, if the probability of the occurrence of the observed data values (when H_0 is true) are smaller than the preset α level, then the data is said to contradict the null hypothesis and a decision is made to reject H_0. A common value for α is .10. [Ref. 28: p. 10]

In significance testing, the critical level (α_R) is defined as the minimum level of significance required to reject the null hypothesis. It is found by comparing the computed test statistic with the tabled chi-square, normal, F, or t values as appropriate and then selecting the corresponding p-value. If the test statistic is between two values in the table, the critical level is determined by interpolating the corresponding p-values.

Throughout this study, the critical levels computed in each analysis were compared to an α level of .10: if α_R was less than or equal to .10 (i.e., sufficiently

small), then the null hypothesis was concluded to be false. Conversely, if the critical level was greater than .10, then H_0 was concluded to be true.

C. DATA ANALYSIS

1. Data Display

Before proceeding with the analysis, a description of this study's data display is presented. In analyzing the test scores, the methods of instructional delivery were coded by group number as listed in Table 6. Also, the results analyzed in this chapter used two different forms of the data:

- ALL - all seventy test scores
- EQUAL - groups of equal size

The second form of data was used because the individual degree of freedom ANOVA technique requires the same number of data points in each group. Since group sizes varied (see Table 6), a random number table was used to reduce the number of data points in each group to eight [Ref. 14: p. 579-82]. The results of this random reduction of test scores is listed in Appendix F, "Input Data."

TABLE 6

TRAINING METHOD CODING

GROUP NUMBER	METHOD	GROUP SIZE
1	Live lecture	10
2	Video presentation	10
3	Silent reading	8
4	Control group	12
5	Audio 1.00	10
6	Audio 1.25	10
7	Audio 1.50	10

2. Techniques of Analysis

To determine if there were any differences among the seven training methods' means, one-way analysis of variance was performed on all of the data using a null hypothesis that all group means were equal and an alternative hypothesis that at least one pair of means were different:

- H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 = \mu_6 = \mu_7$
- H_1: $\mu_A \neq \mu_B$ for some $A = 1,...,7;\ B = 1,...,7;\ A \neq B$.

Two-sample t-tests with null hypotheses of $\mu_A = \mu_B$, $\mu_A \geq \mu_B$, and $\mu_A \leq \mu_B$ ($A = 1,...,7;\ B = 1,...7;\ A \neq B$) were also performed to find out where the individual

differences were if the result of the ANOVA was significant. Since equal variances is an assumption of the two-sample t-test, the two-sample F-test (H_0: $\sigma^2_A = \sigma^2_B$) was performed first. If the critical level computed in the F-test was highly significant ($\alpha_R \leq .05$), then the Welch technique was used to compute the α_Rs instead of t-tests. The Welch technique does not require the variances of the two samples to be equal. Reference 29 contains the procedures necessary for using the one-way analysis of variance and two-sample testing techniques, and these procedures were written into the "All Data ANOVA and Two Sample Tests" computer program in Appendix G.

Another technique used to compare the differences among the training methods was individual degree of freedom analysis of variance. The procedures necessary for using this technique were found in Reference 30 and were written in the "ANOVA and Individual Degree of Freedom Tests" computer program (Appendix G). In addition to performing the one-way and individual degree of freedom analysis of variance techniques on the equal group size data, two-sample tests were also performed.

The results from all four analyses of test scores (initial test, retention test, old question, and new question) are presented in sections F - I of this chapter, while a more detailed output is listed in Appendix H.

D. GOODNESS OF FIT RESULTS

An assumption when using analysis of variance and two-sample tests is that the data came from a normal distribution. The Chi-square goodness of fit test [Ref. 29: pp. 527-37] was used to compare the test scores from the initial test, the retention test , the old questions, and the new questions to normal distributions. To determine if the sample of students chosen had a reference distribution of learning that was normally distributed, the high school grade point averages from the background questionnaire were also compared to a normal distribution.

For each of these five groups of data (initial test, retention test, old question, new question, and GPAs), the test scores from the seven training methods were aggregated. The averages of the seven methods' means and standard deviations were computed and then used as input in the "Chi-square Goodness of Fit"computer program (Appendix G). This program calculated the critical levels required to reject the null hypothesis that the data was normally distributed. Because this data was aggregated, there was a strong possibility that the null hypothesis would be rejected if

one or more of the methods of instructional delivery were significantly more effective. If H_0 was rejected, then the test scores of each training method would have to be compared to separate normal distributions before any further analyses could be preformed. Since all the α_Rs in Table 7 were greater than .10, it was concluded that all of the data was normally distributed, and therefore, no further Chi-square goodness of fit tests were required.

TABLE 7

GOODNESS OF FIT RESULTS

DATA	α_R
Initial test	.235
Retention test	.167
Old question	.138
New question	.504
GPAs	.214

E. ANALYSIS OF THE BACKGROUND QUESTIONNAIRE DATA

Before analyzing the results from the two tests, the data obtained from the background questionnaire was examined to determine if any biasing existed in the seven groups (i.e., to find factor(s) that might influence an individuals' test scores). This was accomplished by performing one-way ANOVA on the data to determine the critical levels required to reject the hypothesis that the group means were all equal. As shown in Table 8, further analysis was required with the two items having α_R's less than .10.

TABLE 8

BACKGROUND QUESTIONNAIRE ANOVA RESULTS

BACKGROUND DATA	α_R
Grade point average	.907
Time since last civilian school	.092
Average amount of sleep each night	.353
Amount of sleep before the initial test	.572
Amount of sleep before the retention test	.081
Years of School completed	.448

1. Amount of Sleep Before the Retention Test

The two-sample tests for equality of means between the group with the least amount of sleep (silent reading: 4.375 hours) and the group with the most amount of sleep (video presentation: 7.15 hours) showed no difference in retention test, old question, and new question scores (Table 9). Hence, it was determined that there was not an effect among the groups due to the amount of sleep received before the retention test.

TABLE 9

SLEEP BEFORE THE RETENTION TEST ANALYSES

TEST	READING	VIDEO	α_R
Retention	22.125	21.30	.64756
Old questions	16.500	16.65	.85960
New questions	5.625	4.65	.45905

2. Time Since Last Civilian School

There were four individuals who were found to have long lengths of time (6, 7, 8, and 10 years) since their last civilian school. As Table 10 shows, these individuals had actual test scores greater than their respective groups' mean test scores the majority of the time (Overall - 9 of 16). Also, those individuals with more scores lower than their respective groups' mean test scores had GPAs less than their group's average GPA (6 & 8 years). Therefore, the length of elapsed time since the individuals attended civilian school appeared to have no effect on their initial or retention test scores.

TABLE 10

ANALYSIS OF TIMES SINCE LAST CIVILIAN SCHOOLING

YEARS	NUMBER OF TIMES ≥ GROUP MEAN	RELATION TO GROUP'S AVERAGE GPA
6	1 of 4	Below
7	3 of 4	Above
8	2 of 4	Below
10	3 of 4	Above
Overall	9 of 16	--------

It was therefore concluded that the background information obtained did not lead to any biasing among the groups.

F. ANALYSIS OF THE INITIAL TEST SCORES

First, an explanation of the data in the individual degree of freedom ANOVA and the two sample testing tables is necessary. The notation ABC = DEF in the individual degree of freedom ANOVA table states that methods A, B, and C have the same mean as methods D, E, and F. In the two-sample testing table, the α_R associated with the notation ABCD $\leq$ E is the maximum α_R for all tests comparing the means from methods A, B, C, and D with the mean of method E.

Immediately following the training session, the initial test was given (Case Study 1 in Appendix B). Each student had a maximum of twenty-five minutes to complete this initial test. As shown in Table 11, a significant difference among the means of the seven methods of instructional delivery was found using one-way analysis of variance. Further analysis (Tables 12 and 13) from all three techniques of comparison (individual degree of freedom ANOVA and two-sample testing with all of the data and with groups of equal size) were consistent in their results:

- it was better to train than not to train
- audio presentations were better than live lectures, video presentations, and silent reading
- silent reading was better than live lectures in the two-sample testing using the equal size data.

TABLE 11

INITIAL TEST: ANOVA RESULTS

DATA	α_R
ALL	.006
EQUAL	.001

TABLE 12

INITIAL TEST: INDIVIDUAL DEGREE OF FREEDOM

H_0: EQUAL MEANS	α_R
4 = 123567	.00100
123 = 567	.00126

TABLE 13

INITIAL TEST: TWO SAMPLE TESTING

DATA	H_0: $\mu_A = \mu_B$	α_R	H_0: $\mu_A \leq \mu_B$	α_R
ALL	123567 = 4	$\leq$ .082	123567 $\leq$ 4	$\leq$ .041
EQUAL	23567 = 4	$\leq$ .017	123567 $\leq$ 4	$\leq$ .059
ALL	567 = 1	$\leq$ .107	567 $\leq$ 1	$\leq$ .053
EQUAL	567 = 1	$\leq$ .019	567 $\leq$ 1	$\leq$ .009
EQUAL	6 = 23	$\leq$ .078	6 $\leq$ 23	$\leq$ .053
EQUAL	5 = 23	$\leq$ .181	5 $\leq$ 23	$\leq$ .091
EQUAL	3 = 1	.093	3 $\leq$ 1	.046

G. ANALYSIS OF THE RETENTION TEST SCORES

Eight to ten days after the training session was administered, the retention test was given (Case Study 2 in Appendix B). Each student had a maximum of thirty-five minutes to complete the retention test. As before, a significant difference among the means of the seven methods was found (Table 14), and therefore, further analysis was required (Tables 15 and 16). The results from the three techniques of comparison were:

- it was better to train than not to train
- audio presentations at normal speed were better than live lectures and video presentations
- audio presentations at 1.25 times normal speed were better than live lectures
- silent reading was better than live lectures.

TABLE 14

RETENTION TEST: ANOVA RESULTS

DATA	α_R
ALL	.04994
EQUAL	.04078

TABLE 15

RETENTION TEST: INDIVIDUAL DEGREE OF FREEDOM

H_0: EQUAL MEANS	α_R
4 = 123567	.00682
123 = 567	.12299

TABLE 16

RETENTION TEST: TWO SAMPLE TESTING

DATA	$H_0: \mu_A = \mu_B$	α_R	$H_0: \mu_A \leq \mu_B$	α_R
ALL	23567 = 4	≤ .071	123567 ≤ 4	≤ .063
EQUAL	23567 = 4	≤ .064	23567 ≤ 4	≤ .032
ALL	5 = 1	.069	5 ≤ 1	.035
EQUAL	5 = 1	.054	5 ≤ 1	.027
ALL	5 = 2	.116	5 ≤ 2	.058
EQUAL	5 = 2	.217	5 ≤ 2	.108
EQUAL	6 = 1	.136	6 ≤ 1	.068
EQUAL	3 = 1	.198	3 ≤ 1	.099

H. ANALYSIS OF THE OLD QUESTION SCORES

The first half of the retention test consisted of questions similar to the ones asked on the initial test. The results of the analyses of these "old" questions are listed in Tables 17, 18, and 19. Here,

- it was better to train using video presentations, silent reading, and audio presentations than not to train
- audio presentations at normal speed or at 1.25 times normal speed, video presentations, and silent reading were better than live lectures

TABLE 17

OLD QUESTIONS: ANOVA RESULTS

DATA	α_R
ALL	.18372
EQUAL	.03929

TABLE 18

OLD QUESTIONS: INDIVIDUAL DEGREE OF FREEDOM

H_0: EQUAL MEANS	α_R
4 = 123567	.00956
123 = 567	.16141
1 = 2	.07648

I. ANALYSIS OF THE NEW QUESTION SCORES

Questions not asked on the initial test but whose topics were discussed during the training session composed the second half of the retention test. The results of the

TABLE 19

OLD QUESTIONS: TWO SAMPLE TESTING

DATA	$H_0: \mu_A = \mu_B$	α_R	$H_0: \mu_A \leq \mu_B$	α_R
ALL	23567 = 4	$\leq$.105	23567 $\leq$ 4	$\leq$.053
EQUAL	2356 = 4	$\leq$.023	23567 $\leq$ 4	$\leq$.067
ALL	5 = 1	.159	5 $\leq$ 1	.080
EQUAL	56 = 1	$\leq$.047	56 $\leq$ 1	$\leq$.023
ALL	2 = 1	.205	2 $\leq$ 1	.102
EQUAL	23 = 1	$\leq$.048	23 $\leq$ 1	$\leq$.024

analysis of these "new" questions are presented in Tables 20, 21, and 22. As shown in these three tables,

- it was better to train than not to train
- audio presentations at normal speed were better than all other methods.

TABLE 20

NEW QUESTIONS: ANOVA RESULTS

DATA	α_R
ALL	.05614
EQUAL	.19699

TABLE 21

NEW QUESTIONS: INDIVIDUAL DEGREE OF FREEDOM

H_0: EQUAL MEANS	α_R
4 = 123567	.03212
123 = 567	.23536

TABLE 22

NEW QUESTIONS: TWO SAMPLE TESTING

DATA	$H_0: \mu_A = \mu_B$	α_R	$H_0: \mu_A \leq \mu_B$	α_R
ALL	13567 = 4	$\leq$.097	123567 $\leq$ 4	$\leq$.084
EQUAL	3567 = 4	$\leq$.066	13567 $\leq$ 4	$\leq$.060
ALL	5 = 12	$\leq$.088	5 $\leq$ 123	$\leq$.095
EQUAL	5 = 12	$\leq$.181	5 $\leq$ 12	$\leq$.090
ALL	5 = 7	.091	5 $\leq$ 67	$\leq$.087
EQUAL	5 = 7	.199	5 $\leq$ 7	.099

J. EFFECTS DUE TO STUDYING

Six students reported studying for the retention test, and hence, the retention test, the old question, and the new question scores of each of these six students were analyzed (three scores from six students equaled eighteen cases). Of the eighteen cases, studying influenced test scores in eight, while the test score's position relative to the mean was unchanged in the remaining ten. Therefore, it was concluded that studying had no adverse effects on the individuals' retention test scores.

K. CONCLUSIONS

As stated in Chapter I, the intent of this study was to determine the most effective and efficient shipboard training methods. This was accomplished by comparing the following factors in each method: the preparation costs (the man-hour investment, the development of a repeatable program, and the lecture length), the material costs, the amounts of productivity lost (a function of the time of day training is held and the length of the lecture), and the amount of knowledge gained. Since the same training document was used during all sessions, the developed program was repeatable and the man-hour investment was the same for all groups. Additionally, all training sessions were held during working hours, and no material costs were incurred. Therefore, the only factors of effectiveness and efficiency remaining to be compared were the amount of knowledge gained (effectiveness) and the length of the training session (efficiency).

In the four areas of analysis (the initial test, the retention test, the old questions, and the new questions), audio presentations at normal speed and at 1.25 times normal speed were consistently the most effective methods of instructional delivery. In addition, as shown in Table 23, there were no significant differences between the means of these two audio presentations. On the other hand, the two most common training methods in the surface Navy (live lectures and video presentations) were less effective in the majority of the comparisons.

Additionally, since both of these audio presentations were completed in less time than the more common types of training, the data suggests that these two methods were also more efficient. Table 24 lists these time savings in minutes and seconds (i.e., the audio presentation at normal speed was completed in five minutes less time than the live lecture).

TABLE 23

CRITICAL LEVELS FOR H_0: $\mu_5 = \mu_6$

DATA	INITIAL	RETENTION	OLD	NEW
ALL	.90000	.32919	.75605	.17443
EQUAL	.74454	.75570	.78251	.43679
Individual Degrees of freedom	.70246	.73411	.74957	.39139

TABLE 24

AUDIO PRESENTATION TIME SAVINGS

COMMON METHOD	AUDIO 1.0	AUDIO 1.25
Live lecture	5:00	12:00
Video presentation	8:45	15:45
Silent reading	1:45	8:45

Therefore, the audio presentation at normal speed and the audio presentation at 1.25 times normal speed were the most effective and efficient methods of instructional delivery in this study. Conversely, the most common shipboard training methods were both less effective and less efficient than the other methods.

The recommendations of this study are presented in the next chapter.

VI. RECOMMENDATIONS

As stated in the preceding chapter, audio presentations at normal speed and at 1.25 times normal speed were the most effective and efficient methods of instructional delivery in this experiment. Additionally, the following conclusions were reached in other studies on audio presentations (stated previously in Chapter II):

1. Trainees who used speech compression finished sooner and were noticeably less fatigued [Ref. 6: p. 17].
2. Due to an increased number of inputs per unit of time (at higher auding rates), there were less lulls during which the mind can wander. Therefore, trainees tended to concentrate more [Ref. 7].
3. Comprehension remained at least constant (in some cases it improved) from 125 to 275 words per minute [Ref. 8].
4. Retention of compressed speech followed the same patterns as it did for listening normally or reading the material [Ref. 8].
5. Students expressed favorable attitudes toward the use of compressed speech as a primary mode for learning as well as a technique for review [Ref. 9].
6. Some poor readers (i.e:, low RGLs) preferred to learn by listening rather than by reading [Ref. 10].

Also, in Reference 31's study, large individual differences were obtained which indicated that there was not one most efficient speed for everyone. However, this was not a problem in this study because no significant differences were found comparing the Audio 1.0 and the Audio 1.25 presentations. Hence, trainees have an ability to adjust the tape recorder to find their most efficient speed. Therefore, in view of these findings, it is highly recommended that variable speed audio presentations be used as a method of instructional delivery in the surface Navy more frequently.

Finally, viewing the results of this experiment, the recommendations for further study are: perform the experiment again (1) using speed listening (simultaneous reading and listening) as an additional method of instructional delivery, and (2) having the same number of trainees in each training method group.

Speed listening is recommended as another training method because studies have found

- it to be an effective alternative to reading [Ref. 32].
- it improves reading comprehension and speed [Ref. 8].

(Also, although not a problem in this study, the reason to have the same number of students in each training method group is to eliminate the random reduction of data

for the individual degree of freedom analysis of variance technique. Thus, all of the data can be used in all of the analyses.)

This study has compared seven methods of instructional delivery to determine the most effective and efficient shipboard training methods. It is hoped that the results of this experiment will be incorporated into existing training programs in the surface Navy.

APPENDIX A

GENERAL DAMAGE CONTROL--FIREFIGHTING

Fire is a constant potential hazard aboard ship. All possible measures must be taken to prevent the occurrence of fire or to bring about its rapid extinguishment. In many cases, fires occur in conjunction with other damage, as a result of enemy action, weather, or accident. Unless fire is rapidly and effectively extinguished, it may easily cause more damage than the initial casualty. In fact, fire may cause the loss of a ship even after the original damage has been repaired or minimized.

Every member of the ship's company must realize their responsibility toward firefighting and the importance of the subject. This paper deals with the fundamentals of firefighting, including the nature of fire, the classification of fires, the fundamentals of extinguishment, the extinguishing agents used, the firefighting equipment and systems that are available, and the basic procedures for combating a fire.

THE NATURE OF FIRE

Fire, also called burning or combustion, is a rapid chemical reaction that results in the release of energy in the form of light and noticeable heat. A fire cannot exist without three things: (1) a combustible material, (2) a sufficiently high temperature, and (3) a supply of oxygen. Because of these three requirements, the process of fire is sometimes regarded as being a triangle with the three sides consisting of FUEL, HEAT, and OXYGEN. The control and extinguishment of fires is generally brought about by eliminating one side of the fire triangle--that is, by removing fuel, heat, or oxygen. The heat of the fire triangle is transmitted in three ways: (1) conduction--heat is transferred through a substance by direct contact, (2) convection--heated gas transferring heat to other combustibles, and (3) radiation--heat is distributed in all directions through the air.

THE CLASSIFICATION OF FIRES

Fires are classified according to the nature of the combustibles (or fuels) involved. The classification of any

particular fire is of great importance, since it determines the manner in which the fire must be put out. Fires are classified as being class A, class B, class C, or class D fires.

CLASS A fires are those occurring in such ordinary combustible materials as wood, cloth, paper, upholstery, and similar materials. Class A fires are usually extinguished with water, using high or low velocity fog or solid streams. Class A fires leave embers or ashes, have white smoke, and they must always be overhauled (broken up).

CLASS B fires are those occurring in the vapor-air mixture over the surface of flammable liquids such as gasoline, lubricating oils, jet fuels, diesel oil, fuel oil, paints, thinners, solvents, and greases. AFFF, dry chemical, carbon dioxide, or water fog can be used to extinguish class B fires. The choice of agent depends upon the circumstances of the fire, with AFFF usually the preferred agent. Class B fires give off a black smoke.

CLASS C fires are those occurring in electrical equipment with a blue flame and either blue or white smoke. Nonconducting extinguishing agents are used for extinguishing class C fires. Carbon dioxide is the preferred agent because it leaves no residue. For complete safety, fires in electrical equipment should be fought only after all current, except as needed for necessary lighting, to the equipment has been shut off. This usually halts the flow of heat to the fuel and it can readily be extinguished.

CLASS D fires are those occurring in combustible metals such as magnesium, titanium, and sodium. If class D fires become heated to a high temperature, they burn with a dazzling white flame. In general, magnesium fires are extinguished only by smothering with dry sand or by a cooling action using large amounts of water from a safe distance.

EXTINGUISHING AGENTS

The agents commonly used by Navy firefighters include water, AFFF, dry chemicals (PKP), and carbon dioxide (CO_2). The agent or agents used in any particular case depend upon the classification of the fire and the general circumstances.

Cooling is the most common method of fire extinguishment, and water is the most effective cooling agent. Fortunately, water is usually available in large quantities. Of all extinguishing agents now used by the Navy, water has the greatest capacity for heat absorption. Therefore, most

burning substances can be cooled below their ignition points by the application of water.

Aboard ship, water is usually applied by means of the all-purpose nozzle. With the all-purpose nozzle, water may be applied as a solid stream, in the form of a high velocity water fog, or in the form of a low velocity water fog. In general, fog is preferred to the solid stream except when it is necessary to reach a fire that is some distance away or when the penetrating power of the solid stream is required. Under other circumstances, the fog is preferable because a given amount of water can absorb more heat when it is in the form of fog than it can when it is in the form of a solid stream. An additional advantage of fog is that it reduces the total amount of water that must be pumped into the ship to fight a given fire; since all water used for firefighting must be pumped overboard or otherwise disposed of, this is a definite advantage.

Aqueous film forming foam (AFFF) is a concentrated mixture that was developed to combat class B fires. It is a clear, slightly amber colored liquid that floats on the surface of hydrocarbon fuels and creates a film which prevents the escape of vapors and consequently prevents ignition. The type used by the Navy is a 6 percent concentration, that is, six parts AFFF mixed with 94 parts of water. AFFF is applied to the fuel surface as a foam. As the AFFF solution drains from the foam, it forms a vapor-tight film on top of the fuel, thereby smothering the fire.

Carbon dioxide (CO_2) is a very effective agent for extinguishing fires by smothering them, that is, by reducing the amount of oxygen available for combustion. This smothering action of carbon dioxide is temporary. The firefighter must remember that the fire can quickly rekindle if oxygen is again admitted to hot embers.

Carbon dioxide is a dry, noncorrosive gas that is inert when in contact with most substances. Carbon dioxide does not damage machinery or other equipment. Since it is a nonconductor of electricity, CO_2 can safely be used in fighting fires that might present electric shock hazards. However, the frost that collects on the horn of the carbon dioxide cylinder IS a conductor of electricity. Therefore rubber gloves should be worn by personnel using CO_2 to extinguish electrical fires.

Although carbon dioxide is nonpoisonous, it is dangerous to the firefighter because it does not provide a suitable atmosphere for breathing. Asphyxiation can result from breathing carbon dioxide. Oxygen Breathing Apparatus' (OBA's) must be worn when CO_2 is used below decks or in confined spaces.

Dry chemical powders extinguish a fire by a rather complicated chemical mechanism. They do not smother the fire and they do not cool it. Instead they interrupt the chemical reaction that is fire by suspending fine particles in the fire. In effect, the dry chemicals put a temporary screen between the heat, oxygen, and fuel and maintain this screen just long enough for the fire to be extinguished.

Several types of dry chemicals have been used as fire extinguishing agents. For Navy use, the most important agent of this kind at present is potassium bicarbonate, also known as Purple-K-Powder or PKP. PKP is used primarily on class B fires, however, it is also safe and effective on class C fires. PKP should NOT be used in lieu of CO_2 unless necessary, because PKP may foul electronic components.

FIREFIGHTING EQUIPMENT AND SYSTEMS AVAILABLE

To fight fires effectively you must have a thorough knowledge of the firefighting equipment and systems that are available on your ship. The numerous fireplugs aboard your ship are served by branches of the firemain system. Most fireplugs are 1 1/2 or 2 1/2 inches in diameter. Fireplugs are so located that any point on the ship can be reached with 50 feet of firehose from each of two or more fireplugs. On large ships any point can be reached with 100 feet of firehose from each of two or more fireplugs. On flight decks any area can be reached with 150 feet of hose from at least two fireplugs.

The two standard Navy firehoses are of double-jacketed cotton and rubber lined, and the newer black collapsible rubber type, used mainly on flight decks, and they come in 1 1/2 inch or 2 1/2 inches in diameter. Firehose is made in 50 foot lengths. The 50-foot lengths of hose are normally referred to simply as "lengths" of hose. Thus 100 feet of hose may be described as two lengths of hose.

The all purpose nozzle, shown in Figure A.1, comes in two sizes: one size fits a 1 1/2-inch hose, the other fits a 2 1/2-inch hose. A single valve controls the three operations of the all purpose nozzle to project a solid stream; to project a fog; and to turn it off. To put the nozzle in operation, the firefighter pulls the bail back from the FORWARD/CLOSED position to the VERTICAL/FOG position, or all the way back to the REAR/OPEN or solid stream position.

Fog is generated in the all purpose nozzle (APN) by either a low velocity fog head attached to an applicator or a high velocity nozzle tip. If a high velocity fog is desired, as shown in Figure A.2, the high velocity tip is left in place in the fog outlet on the nozzle. If a low

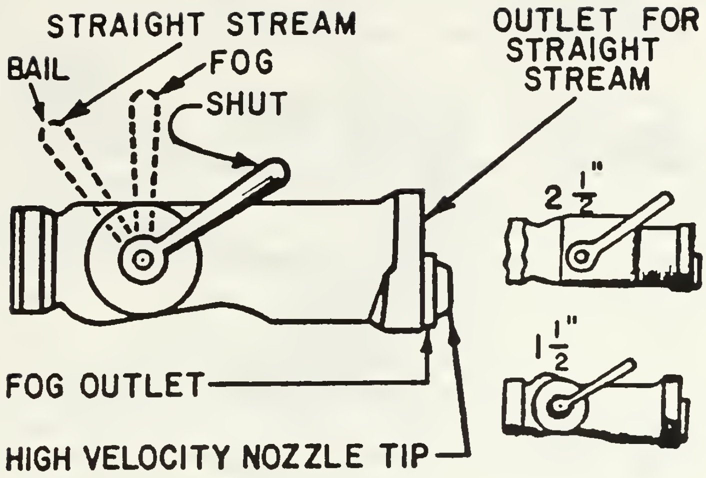

Figure A.1 All Purpose Nozzles

Figure A.2 All Purpose Nozzle on High Velocity Fog

velocity fog is desired, the tip is removed (Figure A.3), and an applicator equipped with a low velocity head is snapped into place in the fog outlet on the nozzle. A bayonet joint (Figure A.4) holds the high velocity tip or the applicator in the nozzle when it is in use. The high velocity tip is permanently attached to the nozzle with a short piece of chain.

When the bail of the 1 1/2 inch all purpose nozzle is moved to the REAR/OPEN position, the nozzle projects a solid stream of water a distance of approximately 65 feet (with 100 psi of firemain available). On the 2 1/2 inch nozzle the projection distance is approximately 75 feet. Water in the form of either a solid stream or fog is effective against class A fires, but a solid stream (Figure A.5) should NOT be used on class B fires where it will have a tendency to spread the fire. In combating class A fires the

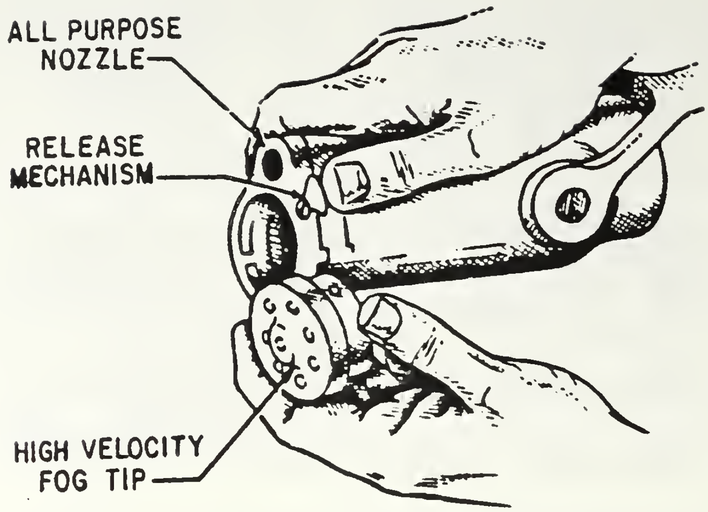

Figure A.3 Removing a High Velocity Tip (APN)

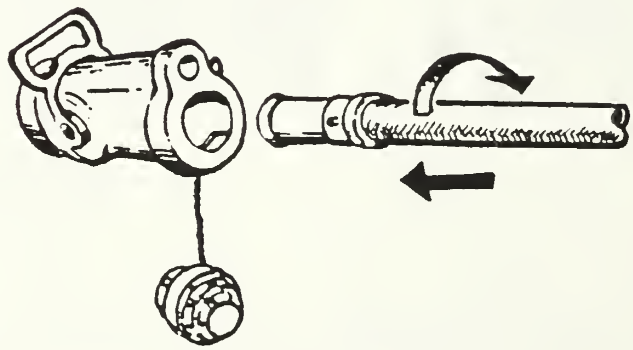

Figure A.4 Bayonet Joint on Applicator (APN)

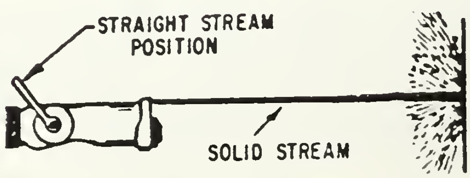

Figure A.5 Solid Stream (APN)

solid stream should be used only for breaking up and penetrating class A material after surface fire has been reduced by water fog (i.e., overhauling the fire).

At 100 psi pressure the high velocity fog stream is projected a distance of more than 20 feet from the 1 1/2 inch nozzle and more than 30 feet from the 2 1/2 inch nozzle. The firefighter is more or less shielded behind the stream and can approach closer to the fire or stand away as the conditions require. Because the water particles do not have the precision or force to reach more than a few feet from the fog head, the low velocity head is never used on the nozzle directly but always with an applicator (Figure A.6). Without the extended reach the applicator gives him, the firefighter would be not only enveloped in a fog of his own making and, therefore, impeded in his work, but also he would have to approach to within a few feet of the fire.

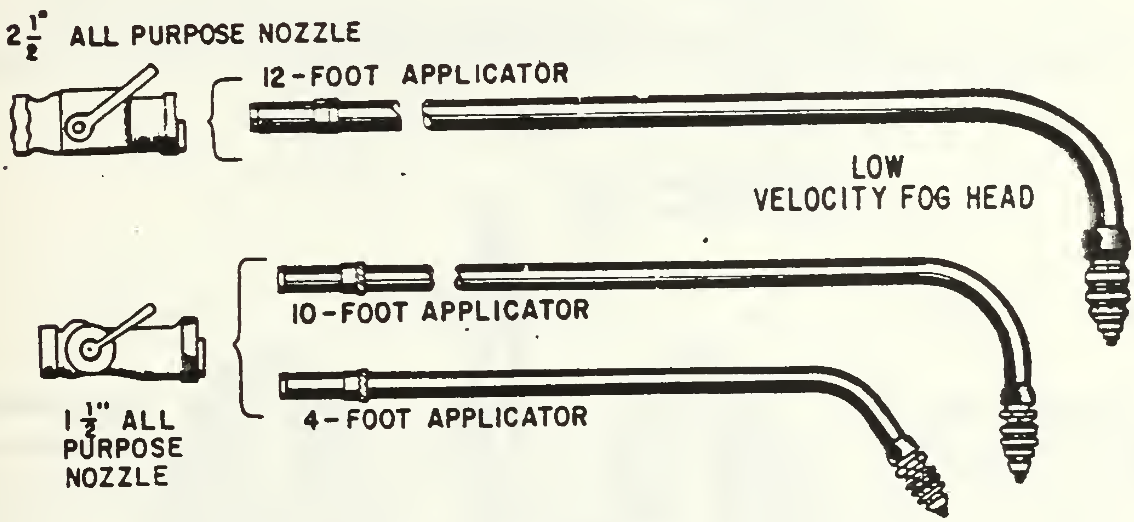

Figure A.6 Standard Applicators

Low velocity 2 1/2 inch piercing applicators (Figure A.7) are issued for aircraft carriers, certain missile-carrying ships, and ships carrying helicopters. The piercing applicator is for shipboard use in aircraft fires for cooling munitions inside the burning aircraft and to assist in the general fire extinguishment problems involved.

Figure A.8 shows a properly made-up fire station.

Figure A.7 Piercing Applicator

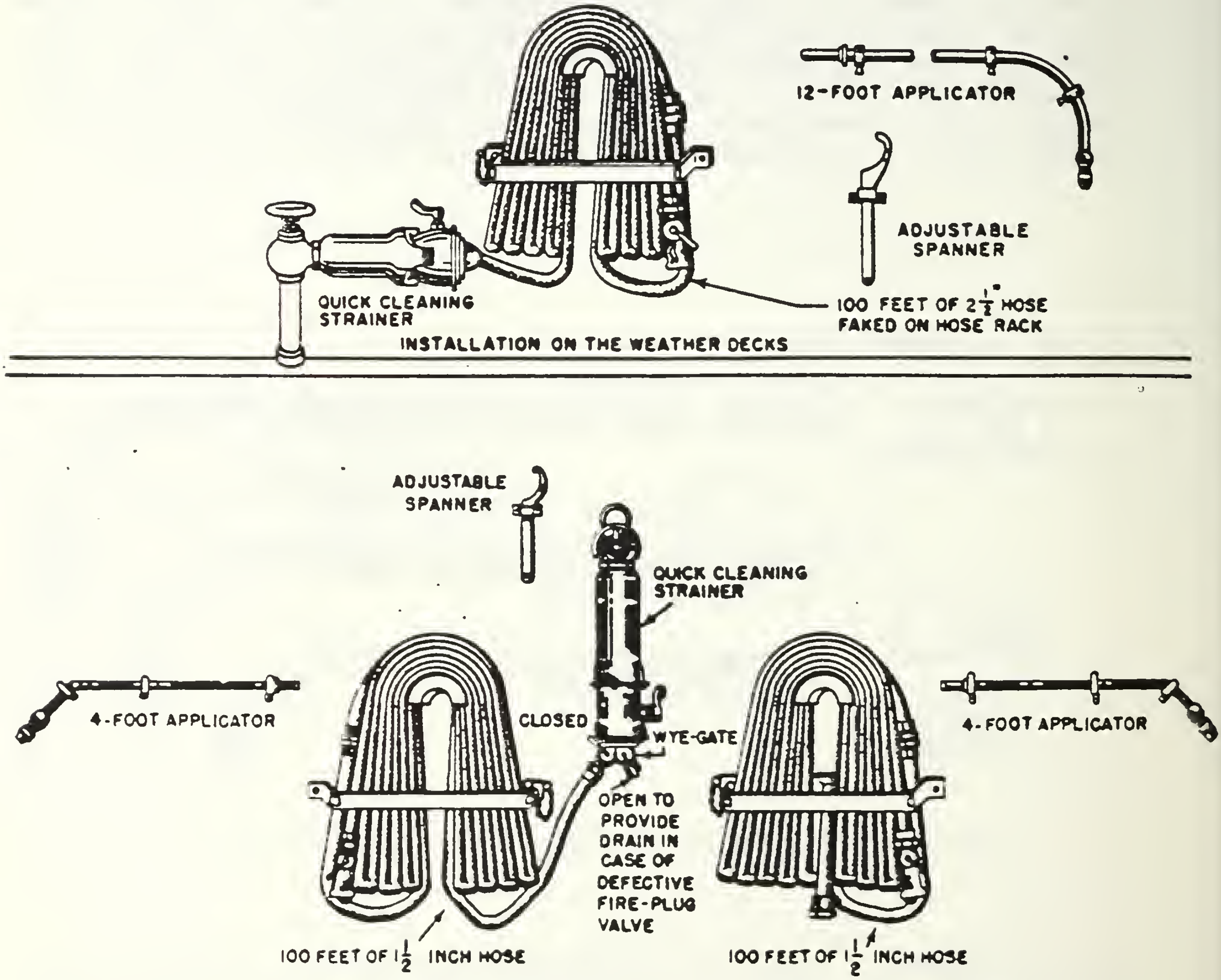

Figure A.8 Fire Hose Properly Rigged at Fire Stations

Now you are ready to fight the fire. At all fires at least two hoses must be rigged with each hose connected to a

separate fireplug. One hose, called the "working" or #1 hose, is the primary firefighting hose and is equipped with a Navy all purpose nozzle. The second hose, called the "backup" or #2 hose, is equipped with an all purpose nozzle and with a low velocity water fog applicator. The backup hose provides low velocity water fog to beat down the smoke and heat from the fire, to protect the firefighters, and to take over from the working hose in the event of a failure in working hose water pressure. (See Figure A.9.)

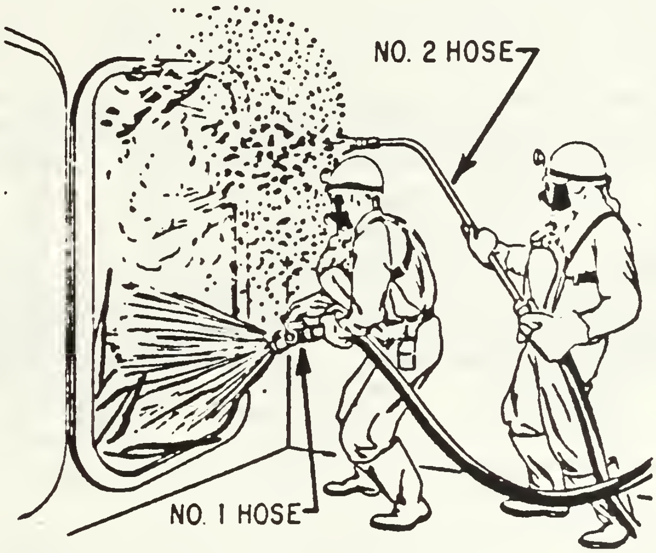

Figure A.9 No. 1 Hose and No. 2 Hose in Action

Either the 1 1/12 inch or 2 1/2 inch hose, equipped with the proper nozzle, should deliver a stream of water that is consistent in volume, in pattern, and in distance. If there is a failure in these, check the lay of the hose to see if there is a double twist (Z kink) which has the tendency to break the stream a few feet from the nozzle or to reduce the pressure. Next, inspect the nozzle tip for a possible obstruction at the edge which can break the stream. If neither of these possibilities is present, the pressure on the stream is probably too low. There should be at least 100 psi at the fireplug to maintain proper delivery of water.

Low nozzle pressure can result from clogging in the quick-cleaning strainer at the fireplug. In view of this possibility, especially in tropical waters where marine growth is plentiful or during battle when concussion shakes

encrustation particles to loose, the handle on the quick-cleaning strainer is pushed downward to the open position which causes a flush to remove the marine growth or encrustation particles trapped in the strainer. Should the flushing operation prove ineffective, immediately lay a line (hose) into the adjoining sectionalized firemain if possible; or in case of ruptures, you should close the stop valves on each side of the rupture, install a jumper line, and then open the closed stop valves to furnish the system with water. (See Figure A.10.)

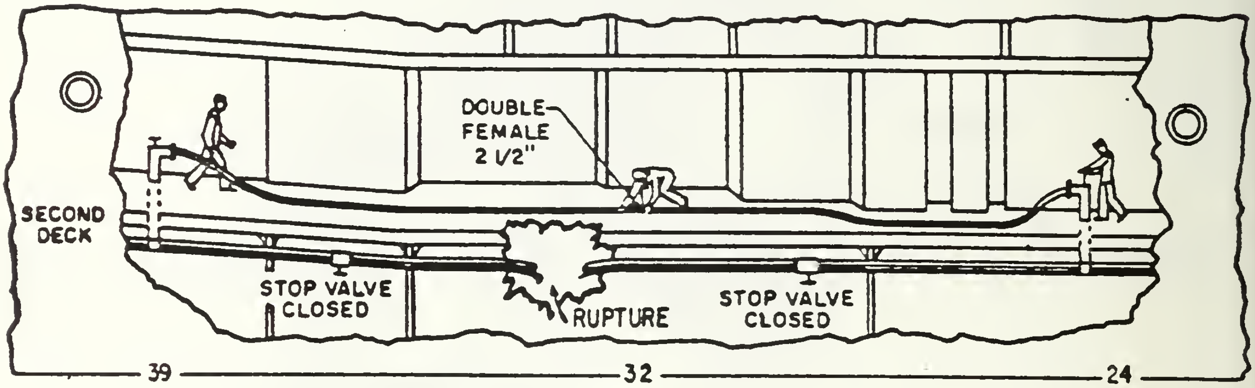

Figure A.10 Installation of a Jumper Line

The firemain system receives water pumped from the sea and distributes this water to fireplugs, sprinkling systems, flushing systems, machinery cooling water systems, washdown systems, and other systems as required. The primary function of the firemain system is to supply the fireplugs and the sprinkling systems; the other uses of the system are secondary.

There are three basic types of firemain systems used on naval ships: the single main system, the horizontal loop system, and the vertical loop system. The type of firemain system installed in any particular ship depends on the characteristics and functions of the ship. Small ships generally have straight-line single main systems. Large ships usually have one of the loop systems or a composite system which is some combination or variation of the three basic types.

A class B firefighting team is made up of men and equipment needed to effectively maneuver two 1 1/2 inch hoses. Each hose is manned by a nozzleman and three to five hosemen. One hose, the "working hose," is a foam hose and has the primary responsibility of extinguishing the fire. The "working hose" is equipped with a mechanical foam nozzle. The second hose, the "backup hose," is a water hose and has the primary responsibility of protecting the firefighting team with low velocity water fog as necessary. The backup hose has a standard Navy all purpose nozzle with a 4-foot applicator attached.

The firefighting team for fighting a class B fire on a hangar deck is made up of two nozzlemen and eight or more hosemen. This team mans two 2 1/2 inch fire hoses. One hose, the "working hose," provides foam for smothering the fire and is manned by a nozzleman and four or more hosemen. The second hose, or "backup hose," provides low velocity water fog to act as a heat shield to protect the personnel. The backup hose is used with the Navy all purpose nozzle and the 12-foot applicator and is manned by a nozzleman and four or more hosemen.

The mechanical foam nozzle and pickup tube are shown in Figure A.11.

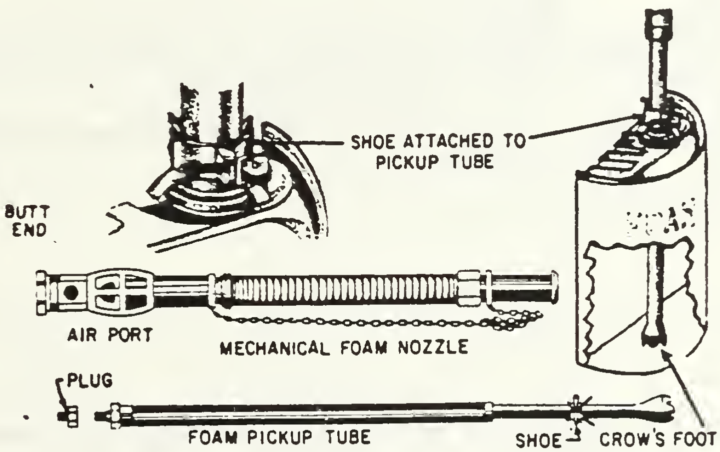

Figure A.11 Mechanical Foam Nozzle and Pickup Tube

The mechanical foam nozzle consists of a 21 inch piece of flexible metal with a metal outlet nozzle. The butt end of the nozzle contains a suction chamber and an air port. The

mechanical foam nozzle is used with the pickup tube attached to it except when foam liquid is introduced by means of an FP-180 water motor proportioner such as the one shown in Figure A.13.

When the pickup tube is used with the mechanical foam nozzle, it is attached by its hose end to the suction chamber in the butt end of the mechanical foam nozzle, just behind the air port. The unit is then called a Navy Pickup Unit (NPU). (See Figure A.12.) The metal pipe end of the pickup tube is inserted into a container of AFFF solution. The contents of one can of liquid (5 gallons) will last approximately 1 1/2 minutes and will produce about 660 gallons of foam in that time.

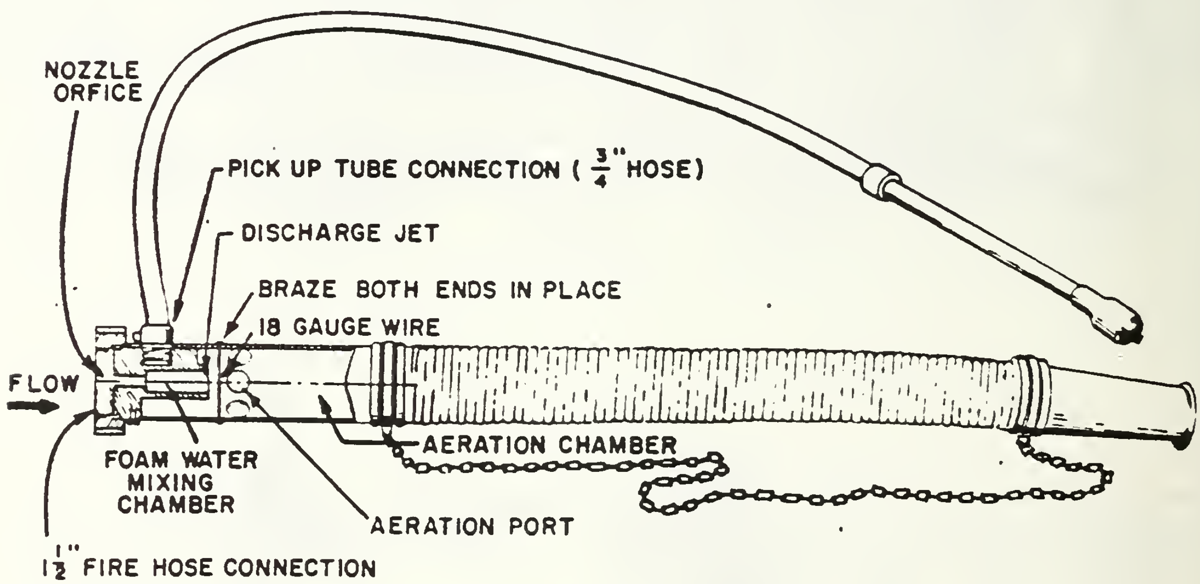

Figure A.12 Navy Pickup Unit (NPU) Nozzle Assembly

The FP-180 water motor proportioner consists of a foam liquid pump driven by a water motor. The unit (Figure A.13) has 2 1/2 inch connections at both the inlet and outlet sides, and it has two 1/2 inch pickup tubes. Flow through the water motor causes the foam pump to inject a measured amount of foam liquid into the water stream when the foam valve is moved to the proper position.

The foam valve has three positions, one for OFF and one for each of the two pickup tubes. A plexiglass sight tube

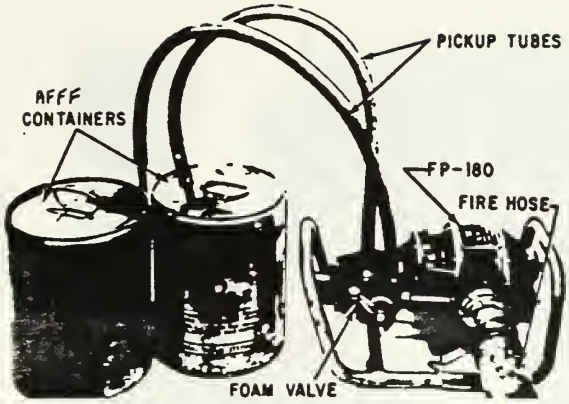

Figure A.13 FP-180 Water Motor Proportioner

allows the operator to determine when to shift from one pickup tube to the other, as an AFFF can become empty. A 5 gallon can of AFFF will last approximately 1 1/2 minutes. A continuous supply of properly mixed foam is thus assured. The FP-180 water motor proportioner may be used also for fighting a fire with water or fog alone. When the foam valve is in the off position, water supplied under pressure will be discharged as water or fog, without the addition of foam.

The FP-180 water motor proportioner may also be permanently installed in some application. An FP-180 foam station consists of an FP-180 proportioner, a 50-gallon tank for the foam liquid, and the associated piping and valves. In a fixed installation, only the OFF position and one FOAM position of the valve are used, because only one pickup tube is used.

Although foam is an excellent agent for fighting fires in flammable liquids, some problems may be experienced in using this agent. In general, poor foam is produced when firemain pressure is inadequate, when the portable or installed foam equipment is not correctly operated, or when the foam equipment is not properly maintained.

Single agent hose reels (Figure A.14) which dispense only AFFF are located on the damage control deck. The damage control deck is normally the first complete deck below the main deck. The AFFF equipment consists of an FP-180 foam station described previously, a 125 foot length of non-collapsible hose, and a nozzle. In continuous operation

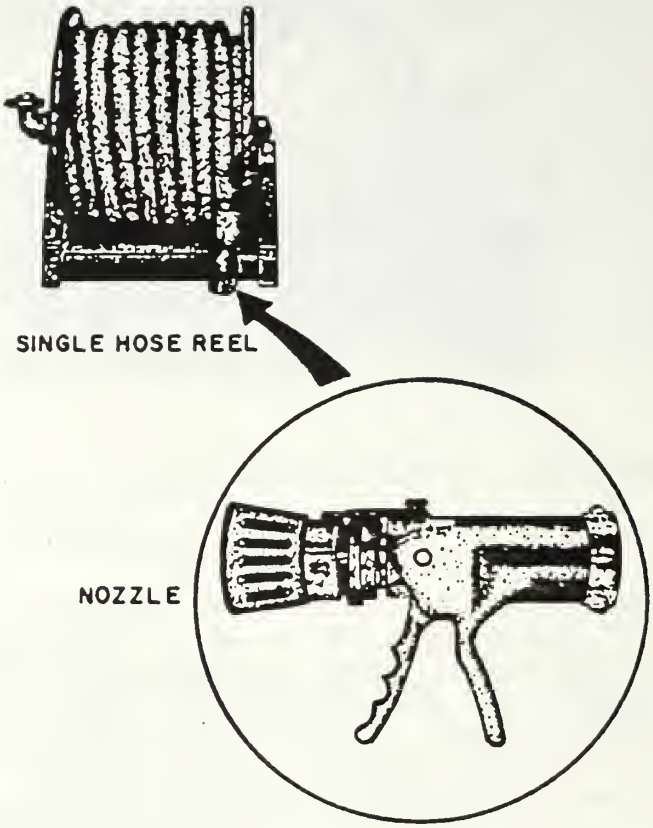

Figure A.14 Single Hose Reel

the 50 gallons of AFFF in the tank will last approximately 7 minutes without refilling the tank.

The AFFF nozzles (see Figure A.15) are used to regulate the flow of AFFF from a hose and cause it to be discharged in a given pattern. This rate of flow and pattern are both adjustable. By rotating the ring on the barrel of the nozzle (see Figure A.16) 60, 95, or 125 GPM can be obtained. The rate of flow is controlled between the center barrel and nozzle stem and determines the amount of AFFF discharged. The nozzle should be preset at the 95 GPM setting for fighting fires in the engineering spaces and at the 125 GPM for flight deck fires.

A twin agent system has been developed and approved for shipboard use. The makeup of the twin agents is AFFF and PKP. PKP interrupts the chemical reaction that is fire, and thus slows down combustion. AFFF provides reflash protection. This is particularly important because the PKP gives

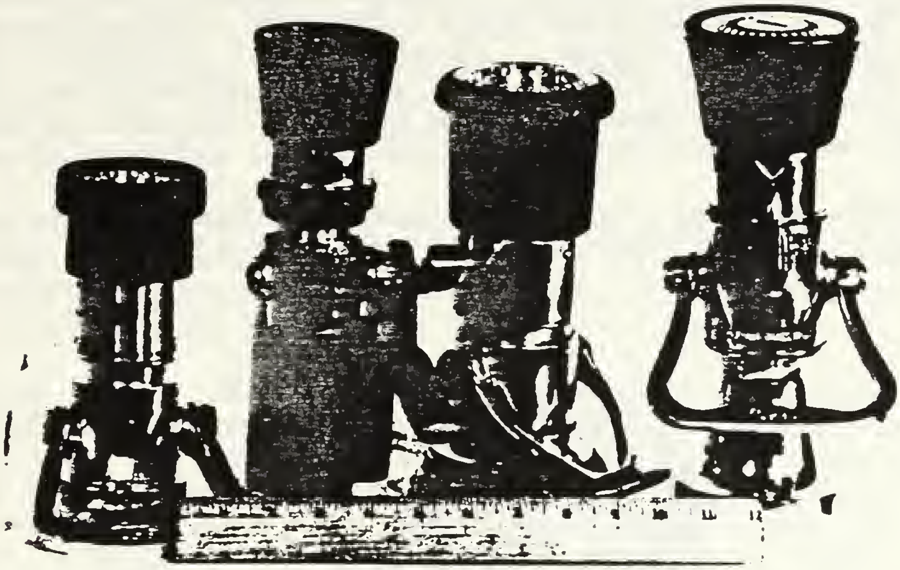

Figure A.15 Various Variable Stream AFFF Nozzles

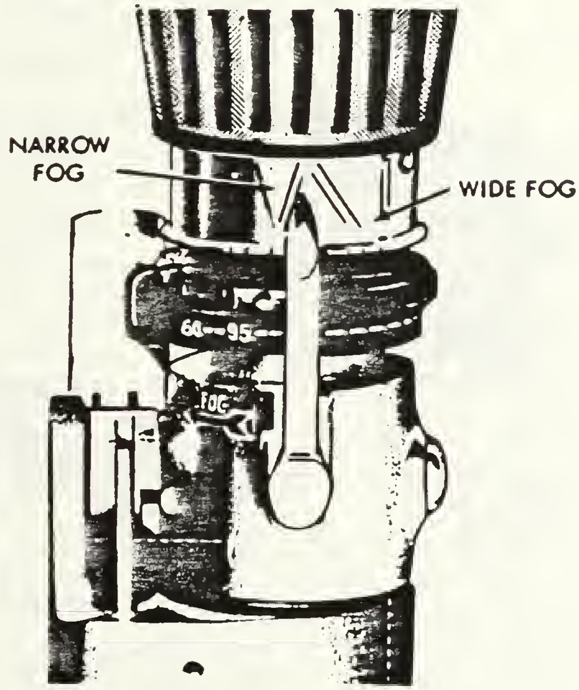

Figure A.16 AFFF Spray Pattern Control

little or no reflash protection. Once the PKP has the fire pushed back, the AFFF is applied so that it floats on the surface of the burning fuel, thereby preventing a reflash from combustible vapors. An additional advantage of AFFF is that it requires only a thin film to cover the liquid (1/2 inch). The twin agent design permits the use of either AFFF or PKP, or a combination of the two to extinguish the fire.

There are two different configurations of the twin agent system. (See Figure A.17.) Configurations A and B each

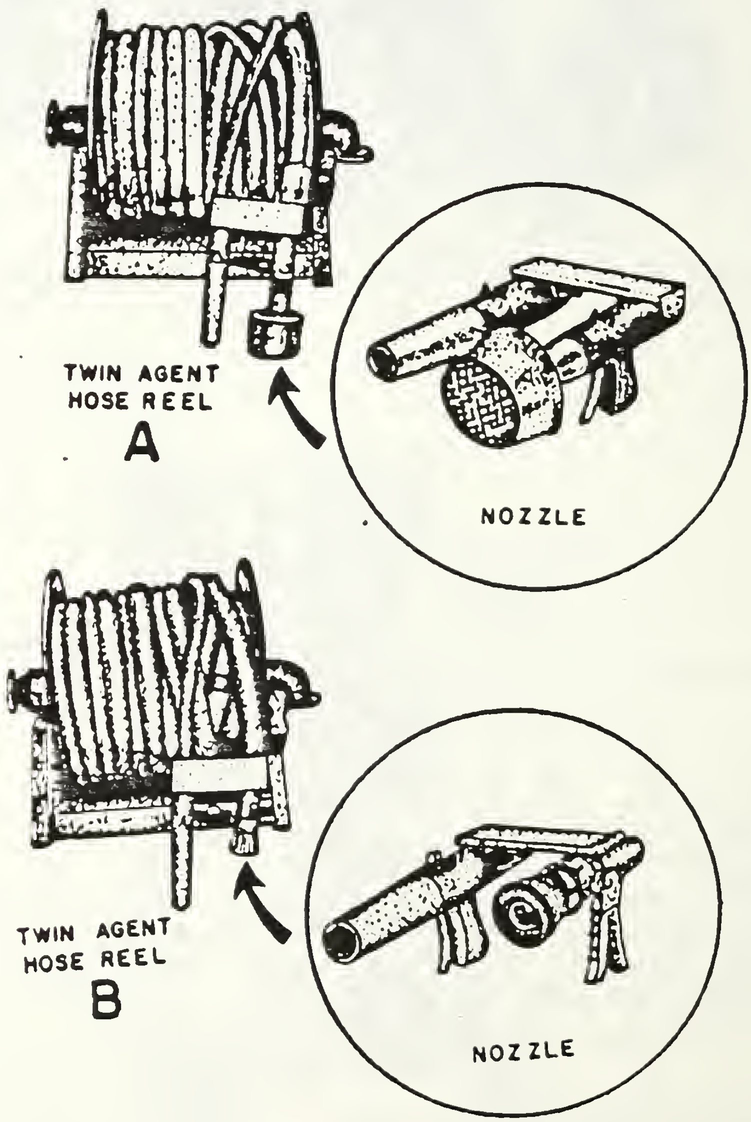

Figure A.17 Configurations of the Twin Agent System

combine the AFFF unit and the PKP unit on a twin agent hose reel which has two hoses--one to dispense AFFF and the other to dispense PKP. The two hoses are married for easier handling. The only distinction between the two configurations is in the design of the nozzles. Although similar in performance, they were designed by two different manufacturers.

Since the twin agent system is used mainly in the engineroom and machinery spaces, the twin agent hose reels are located in these spaces. AFFF is supplied from the damage control deck through a system of pipes.

Aboard ship, carbon dioxide (fire extinguishing equipment includes 15-pound CO_2 portable extinguishers (see Figure A.18), 50-pound CO_2 hose-and-reel installations, and 50-pound CO_2 installed flooding systems. The carbon dioxide is contained under pressure in steel cylinders; it is released through a CO_2 hose or fixed piping when control valves are opened. Any increase in temperature increases the pressure. Since pressure builds up rapidly as the temperature increases, three measures are taken to prevent the danger of explosion:

1. Cylinders are never filled to more than 68 percent of their volume capacity.

2. Cylinders are designed to withstand pressures up to 3000 psi.

3. Whether portable or installed, every carbon dioxide cylinder is equipped with safety release disks to safeguard against the possibility of the cylinder's bursting if excessive pressure should develop as the result of heat.

Because the pressure in a CO_2 cylinder varies with temperature, the amount of carbon dioxide in a cylinder cannot be determined by reading a pressure gauge. Instead, the cylinders must be weighed at least semi-annually to determine the amount of CO_2 contained. When carbon dioxide is released from a cylinder at normal temperatures, it expands rapidly to approximately 450 times its stored volume. This rapid expansion causes the temperature to drop to approximately minus 110^{o}F. Most of the liquid carbon dioxide is vaporized and becomes a gas, but some of it forms "snow." This snow will conduct electricity if it comes in contact with energized equipment and it will blister and burn if it comes in contact with human skin.

Since CO_2 is 50% heavier than air, it tends to settle, covering the fire and excluding air until the fire is

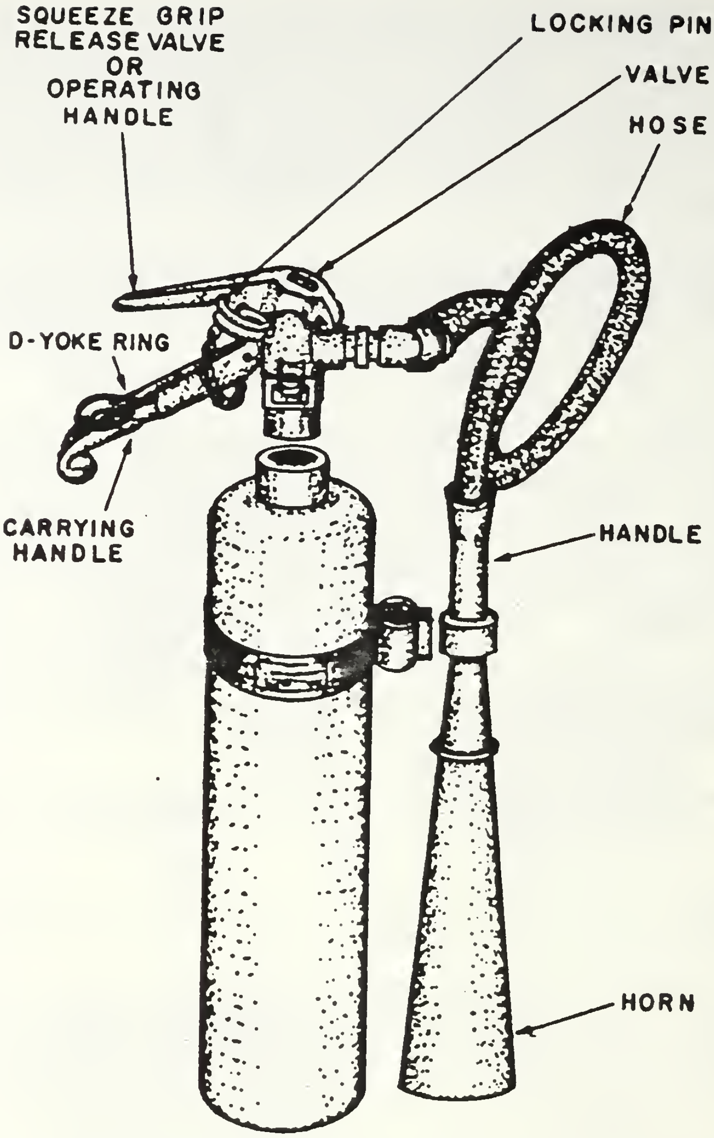

Figure A.18 15-Pound CO_2 Extinguisher

smothered. If there is wind or draft, the firefighter should work so that the carbon dioxide will be drawn or blow over the fire rather than away from it. Although carbon dioxide reaches a very low temperature as it expands from the cylinder, it has only a very slight cooling effect on the fire; it is used primarily for its smothering effect, not for its cooling effect. Since this smothering action of carbon dioxide is temporary, the firefighter must remember that the fire can quickly rekindle if oxygen is again admitted to hot embers.

Carbon dioxide is most effective when it is used in confined spaces. When you are using CO_2 keep the compartment closed and secure the ventilation to prevent unnecessary dilution of the CO_2. Except in an emergency, the firefighter should not open a compartment that has been flooded with CO_2 for at least 15 minutes after it has been flooded. This delay is a precautionary measure to give burning substances time to cool down so that they will not reignite when air is admitted to the compartment.

DO NOT ATTEMPT TO USE CO_2 UNLESS YOU KNOW WHAT YOU ARE DOING. In high concentrations, CO_2 will cause suffocation as rapidly as it will smother a fire, unless proper precautions are taken. If necessary, you can enter a compartment that has been flooded with CO_2 if you use an approved Navy oxygen breathing apparatus (OBA) or an air line hose mask. WARNING: Do NOT use a gas mask because it merely filters the air without adding the necessary oxygen to it. CO_2 has no odor, is colorless, and gives no evidence of its presence that can be recognized by human senses.

The 15-pound portable CO_2 extinguisher is very simple to operate. Merely remove the locking pin and squeeze the "squeeze-grip" release valve. Direct the flow of the CO_2 toward the base of the flame. The maximum effective range of a 15-pound CO_2 extinguisher is 5 feet from the outer end of the horn and will last for approximately 40-45 seconds of continuous use. Move the horn slowly from side to side and advance on the flames as they recede. The squeeze-grip release valve makes a tight seal when pressure on the grip is released; therefore, any unexpended CO_2 is held indefinitely without danger of leakage. When continuous operation is necessary, or when the valve is to remain open for recharging, slip the D-ring on the carrying handle over the operating handle. The operating handle should be in the depressed position when you put on the D-ring. This action will permit continuous operation of the extinguisher, as long as any CO_2 remains.

Portable CO_2 extinguishers are placed throughout the ship at strategic points.

Carbon dioxide is a dry, noncorrosive gas that is inert when in contact with most substances. Carbon dioxide does not damage machinery or other equipment and leaves no residue. Since it is a nonconductor of electricity, carbon dioxide can be used safely in fighting fires that might present electrical shock hazards. However, the frost or snow that collects on the horn of the carbon dioxide cylinder IS a conductor of electricity.

Installed CO_2 systems are put in naval ships to provide a dependable and readily available means of flooding (or partial flooding) certain areas that present unusual fire hazards. An installed CO_2 extinguishing system has one or more 50-pound cylinders. Except for size and releasing mechanisms, the 50-pound cylinders are essentially the same as the 15-pound portable cylinders. There are two types of installed CO_2 systems: the hose-and-reel installation and the flooding system. The flooding system is used in spaces that are not normally occupied by personnel and are located in areas such as paint and inflammable liquid storerooms, paint mixing and issue rooms. The hose-and-reel installation is normally located in machinery spaces such as engine-rooms, firerooms, and diesel generating rooms.

PKP is supplied in 18- and 27-pound portable dry chemical extinguishers (see Figure A.19). Most of these extinguishers are of the cartridge type having the charge of CO_2 in a small cartridge on the outside of the shell. The extinguishing shell is not pressurized until the extinguisher

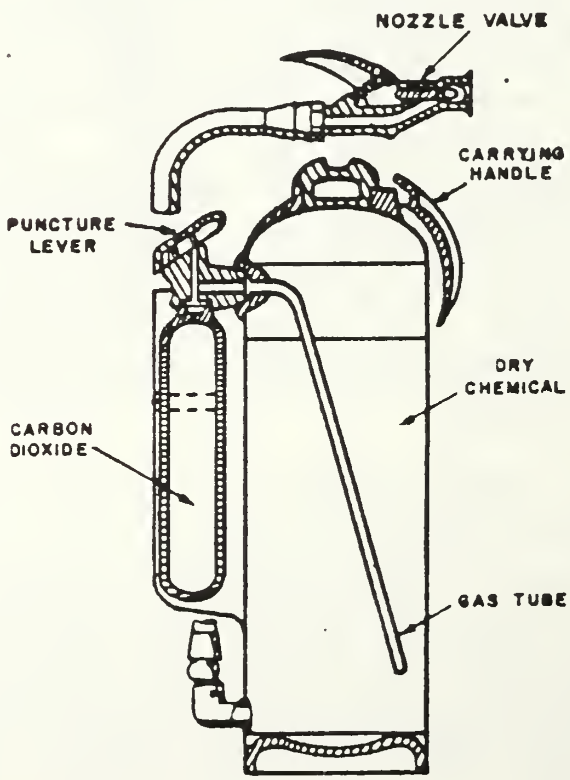

Figure A.19 Dry Chemical Extinguisher

is to be used. To use the PKP bottle, stand to the side of the bottle and push down on the puncture lever (marked push) to cut the seal of the CO_2 cartridge. The CO_2 will fill the extinguisher, and it is ready to use. Approach the fire from the windward side, no closer than 8 feet, if possible. Hold the extinguisher in one hand and the nozzle in the other hand. Discharge the dry chemical by squeezing the squeeze grip on the nozzle. Hold the nozzle firmly and direct the dry chemical to the base of the flame. Use a wide sweeping motion from side to side to apply a dense, wide cloud of dry chemical in the area of the fire. If heat radiated by the fire is intense, a short burst of powder into the air will serve as a heat shield between the advancing firefighter and the fire. In confined spaces it is important that the PKP will be discharged only in short bursts. Unnecessarily long discharges will reduce visibility, render breathing difficult, and waste the agent. This particular type extinguisher has an effective range of approximately 20 feet from the end of the nozzle and will last for approximately 18-20 seconds of continuous use (18-pound bottle).

PKP bottles are installed in all galley spaces and in all machinery spaces where there is a danger of class B and class C fires.

REPORTING A FIRE/INITIAL ACTIONS

The first thing to do when you discover a fire is to REPORT it to the OOD, if your ship is inport or underway. You can take this action in person or by telephone, whichever is quicker. Identify the class of fire, its location, and your name. The location should include the number of the nearest frame (example: third deck, frame 50, starboard side) or the compartment number (example: 3-50-1-L, CPO berthing compartment). Speed is essential. Above all, be accurate in giving the location of the fire; then, spread the alarm. Make sure all people in the surrounding area are aware of the fire and set condition ZEBRA (fire boundaries) in the area. After you have done this, you must take corrective action. If the fire is small, grab a CO_2 bottle and put it out; if the fire is fairly large, rig hoses and fight the fire until the fire party gets to the scene at which time you will be relieved. Before getting relieved, ensure the fire party leader knows the complete situation. If you can contain the fire at its earliest stage, you should be able to put it out in a few minutes. When a fire alarm is sounded on a Navy vessel, the fire-fighter goes into immediate action and proceeds with a

general plan. He must quickly determine the answers to the following questions:

1. Where is the fire?

2. What is burning?

3. What is the extent of the fire?

4. What combustibles are in the vicinity of the fire, in all surrounding spaces, and in the compartments above and below?

5. What vents and other channels are likely to facilitate the spread of fire?

6. Is the firemain furnishing sufficient pressure?

7. What method of extinguishment is indicated?

8. What are the best procedures to prevent the spread of fire and to put out the fire?

Preventing the spread of fire is a vital part of shipboard firefighting, and it is a job that must be undertaken simultaneously with the job of fire extinguishment. A fire that is properly contained so that it cannot spread is well on the way to being controlled.

The first method of preventing the spread of fire is to set fire boundaries. When the firefighter learns the location of the fire, what is burning, and the extent of the fire, he establishes fire boundaries around areas within which extreme precautions are observed. This is to prevent the fire from spreading. Within these boundaries, doors, hatches, manholes, vent ducts, and all other openings not already closed are closed as circumstances warrant and as far as it is practicable to do so without interfering unduly with the operation of the ship. The firefighter is aware that a fire in a compartment means that he has, in effect, a fire in a metal box that is sending out heat in all directions. Not only does heat pass by conduction and radiation through the four bulkheads of the compartment on fire, but also it passes in the same manner down through the deck and up through the overhead. All bulkheads and the deck and the overhead of a compartment on fire must be cooled for two reasons:

1. To prevent the spread of the fire to combustibles in adjacent compartments, and

2. To prevent the heat from weakening and distorting these structures.

The firefighter may remove the combustibles from the immediate vicinity of the fire, especially when the combustibles present a great hazard such as those presented by gasoline and explosives. He may remove them to a safe distance or he may jettison them. Since it is not always possible or practicable to remove the combustibles from the vicinity of the fire, the firefighter may fill the compartments with CO_2 and seal the compartment, or he may depend on cooling and smothering the combustibles with fog spray, or he may flood the compartment with steam or with water through a sprinkling system. On occasion, fuel may be pumped to other tanks.

While the work of preventing the spread of fire is underway, the work of extinguishment is not neglected. These actions are undertaken simultaneously and they are equally important. The experienced firefighter will probably say that confining a fire within bounds is the most important of the two actions. He considers that a fire so confined is definitely under control. His main problem then is to put the fire out and, until the equipment best suited for the task can be put into operation, he uses whatever effective equipment there is at hand.

Another important phase of preventing the spread of fire has to do with the correct operation and maintenance of the ventilation system. The question of whether or not to secure the ventilation system during firefighting operations depends upon the particular circumstances existing at the time. It is important to remember, however, that any ventilation system can provide a means by which fire may spread from one compartment to another--indeed, from one end of the ship to the other.

The danger of spreading fire through ventilation systems is particularly great if there is dirt or dust in the ductwork, on screens, or in any other part of the ventilation system. It is very important, therefore, to make sure that the ventilation systems are inspected regularly and cleaned as often as necessary.

Finally, overhauling the fire also prevents the spread of fire. After a fire has been extinguished, it must be overhauled to make sure that it will not start burning again. The general procedures for overhauling a fire include breaking up combustible materials with a fire axe or fire rake and cooling the fire with water or fog. Since many fires can flare up again after they appear to be out, it is

usually necessary to set a reflash watch after a fire has been extinguished and overhauled.

APPENDIX B
CASE STUDIES AND ANSWER KEYS

1. CASE STUDY 1

You are a roving watch on a DDG inport. It is after working hours, so only the duty section is onboard. As you are walking towards the operations department berthing, you notice a large amount of flames and white smoke coming out of the compartment.

1. (9) FULLY describe all of your initial actions until the fire party arrives.
2. (3) What three things make up a fire?
3. (2) Besides white smoke, what are two other characteristics (descriptors) of the class of fire described above?
4. (2) What is the primary method of extinguishment for this fire, and how does it put out the fire?

You are now the on-scene leader (the person in charge of the fire party at the scene of the fire). It is your responsibility to ensure that the correct firefighting equipment is used and that it is properly set up to combat the class of fire described in part A.

5. (9) Explain FULLY how you would set up your firefighting equipment.
6. (1) Describe the number and type of personnel on your teams.
7. (4) What is the purpose of each of your teams?
8. (5) While fighting the fire you notice a problem with the flow of water. What will you check in order to find the cause of the problem?

On your next duty day while working in the forward machinery room, a class C fire occurs while the electricians are testing a new pump. You report the fire.

9. (2) How could you tell it was a class C fire?
10. (1) What is the FIRST thing you would do in fighting this fire?
11. (2) What is the preferred extinguishing agent for this class of fire and why is it preferred?
12. (6) How does this extinguishing agent put out the fire, what are its major characteristics (maximum effective range and how long will it last in continuous operation), and what are the major safety precautions of using this agent.
13. (1) If the preferred extinguishing agent for this class C fire was not available in the immediate area, what is the next most preferred extinguishing agent?

14. (3) How does this agent put out a fire, and what are its major characteristics (range and time of continuos operation)?

2. ANSWER KEY 1

1.

   a. (1) report it to the OOD

   b. (3) class A fire, operations department berthing, their name

   c. (1) inform all personnel in the surrounding area

   d. (1) set fire boundaries (material condition ZEBRA)

   e. (3) take initial corrective action (for a large fire)

      - rig firefighting equipment and start to fight fire
      - stay until the fire party arrives
      - give a turnover of the situation to the fire party leader

2. (3) heat, fuel, oxygen

3. (2) solid combustibles, leaves an ash

4. (2) high velocity fog (water), cooling

5.

   a. (3) two 1 1/2 inch hoses from two different fireplugs

   b. (3) 1 hose is the working hose with an APN in the VERTICAL/FOG position for high velocity fog

   c. (3) 1 hose is the backup hose with an APN in the VERTICAL/FOG position with a 4-foot applicator inserted for low velocity fog

6. (1) 1 nozzleman with 3-5 hoseman

7.

   a. (1) working hose - put out the fire

   b. (3) backup hose - beat down the smoke and heat from the fire; protect the firefighters, and take over from the working hose in the event of a failure in working hose water pressure

8. (5) Z kink, nozzle tip obstruction, water pressure less than 100 psi, clog in the marine strainer, and a rupture in the firemain

9. (2) blue flame with blue or white smoke, electrical equipment

10. (1) secure the power to the electrical equipment

11. (2) CO_2, it does not leave a residue/foul the equipment

12.

   a. (1) it smothers the fire

   b. (2) 5 feet, 40-45 seconds of continuous use

c. (3) frost on the horn will conduct electricity; frost is at -110 F and can burn/blister the human skin; and CO_2 can cause suffocation (asphyxiation), an OBA must be worn

13. (1) PKP

14.

a. (1) breaks up the chemical reaction

b. (2) 20 feet, 18-20 seconds of continuous use

3. CASE STUDY 2

A. It is a week later and you are on another roving watch. As you enter the after motor generating room, you notice a blue flame coming from the electrical switchboard. You report the fire.

1. (4) Who do you report the fire to and what do you report?
2. (1) Besides a blue flame, what is another characteristic (descriptor) of this class of fire?
3. (3) What three things make up a fire?
4. (1) What is the FIRST thing you would do in fighting this class of fire?
5. (2) What is the preferred extinguishing agent for this class of fire and why is it preferred?
6. (1) How does this extinguishing agent put out the fire?
7. (3) What are the major safety precautions of using this agent?

B. Later in your watch, after the first fire was put out, you notice some sheets, some mattresses, and some paper on fire in first division's berthing.

1. (3) What class of fire are you going to report and what are two other characteristics (descriptors) of this class of fire?
2. (2) What is the primary method of extinguishment for this class of fire and how does it put the fire out?
3. (4) What are the purposes of the two hose teams?
4. (3) What are the three methods of preventing the spread of fire that must be done at the same time you are fighting the fire?

C. During your rounds you pass the paint/flammable liquid storeroom, which is normally not manned.

1. (1) What type of installed firefighting system would you expect to find in this space?

D. The next day, since you are a member of the helicopter firefighting team, you must attend the helicopter fire drill on the flight deck.

1. (1) Since you know that AFFF is the preferred extinguishing agent for flight deck fires, what GPM flow rate is the AFFF nozzle on the #1 hose preset to?

2. (2) What type of applicator will be used on the #2 hose in fighting this fire and why?

3. (1) If all of a sudden, you notice a very, very bright flame coming from the wheels of the helicopter, what class of fire would this be?

4. (2) What are the two preferred extinguishing agents for the fire described in question 15?

E. On your next duty day, while on the damage control deck, you notice large amounts of black smoke coming out of the passageway to a forward engineering space.

1. (3) What class of fire is this, what is the preffered extinguishing agent, and how does this agent put out the fire?

2. (1) What is the proper "mixture" when using this agent?

3. (3) What pieces of equipment, portable and installed, are used to produce this proper mixture?

4. (1) When using a 5 gallon can of this preferred extinguishing agent with one of the pieces of equipment described in question 19, approximately how long will one can last?

5. (2) If the #1 nozzleman is using the twin agent system to fight this fire, in what spaces could he be in?

6. (2) What two extinguishing agents make up the twin agent system?

7. (3) How do these two agents work together?

8. (1) What flow rate is the nozzle of the #1 hose preset to in order to fight a fire in these spaces?

4. ANSWER KEY 2

A.

1.

   a. (1) to the Officer of the Deck (OOD)

   b. (3) class C fire, after motor generating room, their name

2. (1) electrical equipment

3. (3) fuel, heat, oxygen (air)

4. (1) secure the power to the electrical equipment

5.

   a. (1) CO_2

   b. (1) does not leave a residue/does not foul the equipment

6. (1) smothers the fire

7. (3) frost on the horn conducts electricity; frost comes out at -110 F, can burn/blister the human skin; and CO_2 can cause suffocation (asphyxiation), an OBA must be worn

B.

1.

a. (1) class A fire

b. (2) white smoke, leaves an ash

2.

a. (1) high velocity fog (water)

b. (1) cools the heat

3.

a. (1) working hose - puts out the fire

b. (3) backup hose - beat down the smoke and heat from the fire; protect the firefighters; and take over from the working hose in the event of a failure in working hose water pressure

4. (3) setting fire boundaries, securing ventilation, and overhauling the fire (breaking it up)

C.

1. (1) CO_2 flooding system

D.

1. (1) 125 GPM

2.

a. (1) two 1/2 inch (12 foot long) piercing applicator

b. (1) used for cooling munitions inside the burning aircraft and to assist in the general fire extinguishment problems involved

3. (1) class D fire

4. (2) dry sand, large amounts of water (jettison)

E.

1.

a. (1) class B fire

b. (1) AFFF

c. (1) it smothers the fire

2. (1) 6% AFFF, 94% water

3. (3) Navy Pickup Unit (NPU)/Mechanical Foam Nozzle, portable FP-180, and an installed FP-180

4. (1) approximately one 1/2 minutes

5. (2) engineroom, fireroom

6. (2) AFFF and PKP

7.

a. (1) PKP pushes the fire back and interrupts the chemical reaction (slows down the rate of combustion)

b. (1) PKP has no reflash capability

c. (1) AFFF provides the reflash capability

8. (1) 95 GPM

APPENDIX C
DAMAGE CONTROL GLOSSARY

• AFFF	Aqueous Film Forming Foam- foam used to combat class B fires
• agent	what is used to put out a fire, i.e. water, AFFF, PKP,CO_2,etc.
• aircraft	surface ship designed to carry airplanes and helicopters
• applicator	a piece of pipe with a low velocity fog head attached to one end. The applicator snaps in the all purpose nozzle and is used on the #2 hose.
• carbon-dioxide	(CO_2)- agent used to combat class A,B, and C fires
• casualty	an accident; a problem
• combustion/combustible	able to be burned; a fire
• compartment	a room onboard a ship
• effective	works well against something
• electrical	uses electricity
• engineroom	room on the ship where the main engines are located
• equipment	machinery, firefighting gear, etc.
• extinguish	to put out (i.e. to put out a fire)
• fireroom	room on a ship where the boilers are located
• function	job; what a piece of equipment is designed to do
• GPM	gallons per minute
• grip	place where to put your hand
• helicopter	aircraft with rotary blades
• in-port	in a harbor tied up to a pier
• installed	a piece of equipment that was put on a ship for permanent use
• liquid	not solid or gas; takes the shape of its container
• main	most important; primary
• missile	a weapon
• naval	something to do with or belonging to the Navy
• nozzle	a device placed on the end of a firehose so that a desired pattern of an extinguishing agent can be achieved

• Occurs/Occuring/Occurred	something that happens/that is happening/that has happened
• OOD	Officer of the Deck - person in charge of ensuring the daily routine occurs
• oxygen	the air component of the fire triangle
• port	left side of the ship
• purple-k-powder	PKP- agent used to combat class B and C fires
• purpose	job to do; function to perform
• rig	to put together
• smother	to take away the oxygen (air)
• starboard	right side of the ship
• supply	to give; to furnish
• system	pieces of equipment used together for a specific purpose
• underway	at sea
• unit	a piece of equipment by itself; a component
• valve	a piece of equipment designed to direct the flow of a liquid in piping
• ZEBRA	material condition on a ship to be set at general quarters (i.e., close all doors, hatches, vent ducts, etc.)

APPENDIX D
BACKGROUND QUESTIONNAIRE

Social Security Number

Home of Record

Grade Point Average

Amount of Civilian Schooling Received

Location of School

Last Time In School

Favorite Subjects

Navy Schools Attended

PQS Completed

PQS in Progress (% completed)

Job Experiences

Hobbies/Volunteer Work

Number of Books Read in the Last Year

Types of Books Read

Title of Last Book Read

Magazines Enjoy/Subscriptions Owned

Favorite TV Shows

Average Amount of Sleep Received Each Night

Amount of Sleep Received Last Night

APPENDIX E
READABILITY ANALYSES

Readability is the ease or difficulty of reading, while the readability level is a grade level equivalent of the article. Three common methods used in this study to measure readability were the Dale-Chall Formula, the Fry Readability Graph, and the Gunning Fog Index.

1. DALE-CHALL FORMULA (REFERENCE 27)

This formula is based on two counts - average sentence length and percentage of unfamiliar words (words outside the Dale-Chall list of common words). The procedures are as follows:

1) Select samples - for articles, select four 100-word samples for every 2000 words. Never begin or end a sample in the middle of a sentence. (Since Appendix A has 5630 words, twelve samples were chosen).

2) Count the number of words in the sample (W).

3) Count the number of sentences in the sample (S).

4) Count the number of unfamiliar words in the sample (U).

5) Compute the average sentence length (L):

$$L = W / S \qquad \text{(eqn E.1)}$$

6) Compute the percentage of words outside the Dale-Chall list (P):

$$P = (U / W) \times 100 \qquad \text{(eqn E.2)}$$

7) Compute formula raw score (RS):

$$RS = (.0496 \times L) + (.1579 \times P) + 3.6365 \qquad \text{(eqn E.3)}$$

8) The equivalent grade levels corresponding to the formula raw scores are listed in Table 25.

TABLE 25

DALE-CHALL CORRECTION TABLE

Formula Raw Score (RS)	Equivalent Grade Level
4.9 and below	4th grade and below
5.0 to 5.9	5-6th grade
6.0 to 6.9	7-8th grade
7.0 to 7.9	9-10th grade
8.0 to 8.9	11-12th grade
9.0 to 9.9	13-15th grade (college)
10.0 and above	16-(college graduate)

2. FRY READABILITY GRAPH (REFERENCE 4)

To determine the equivalent grade level using this method, two quantities are needed: average sentence length and number of syllables. The procedures are as follows:

1) Select samples - the same samples were used as in the Dale-Chall method except each sample was exactly 100 words in length (required for this method).

2) Count the number of complete sentences in the sample (S). If the last sentence is incomplete, then count the number of words from this last sentence that are in the 100-word sample (I), count the number of words outside the sample (O), and add the percentage:

$$S = S + (I / (I + O)) \qquad \text{(eqn E.5)}$$

3) Count the number of syllables in the sample (N).

4) Enter the Fry Readability Graph (Figure E.1) with S and N to find the equivalent grade level.

3. GUNNING FOG INDEX (REFERENCE 12)

The index is determined by computing the average sentence length and the percentage of polysyllable words (words with three or more syllables). The procedures are as follows:

1) Select sample - the same samples were used as in the Dale-Chall method except the word count was not the same.

2) Count the number of words in the sample (W). Each word in the sample was counted consecutively up to 100 words. If the closest sentence ending with a period was past the 100 word mark, then those extra words were added to the word count. If the closest sentence ending with a period was before the completed 100 word mark, then only the amount of words up to that last completed sentence was counted.

3) Count the number of sentences in the sample (S).

4) Compute the average sentence length of the sample (L):

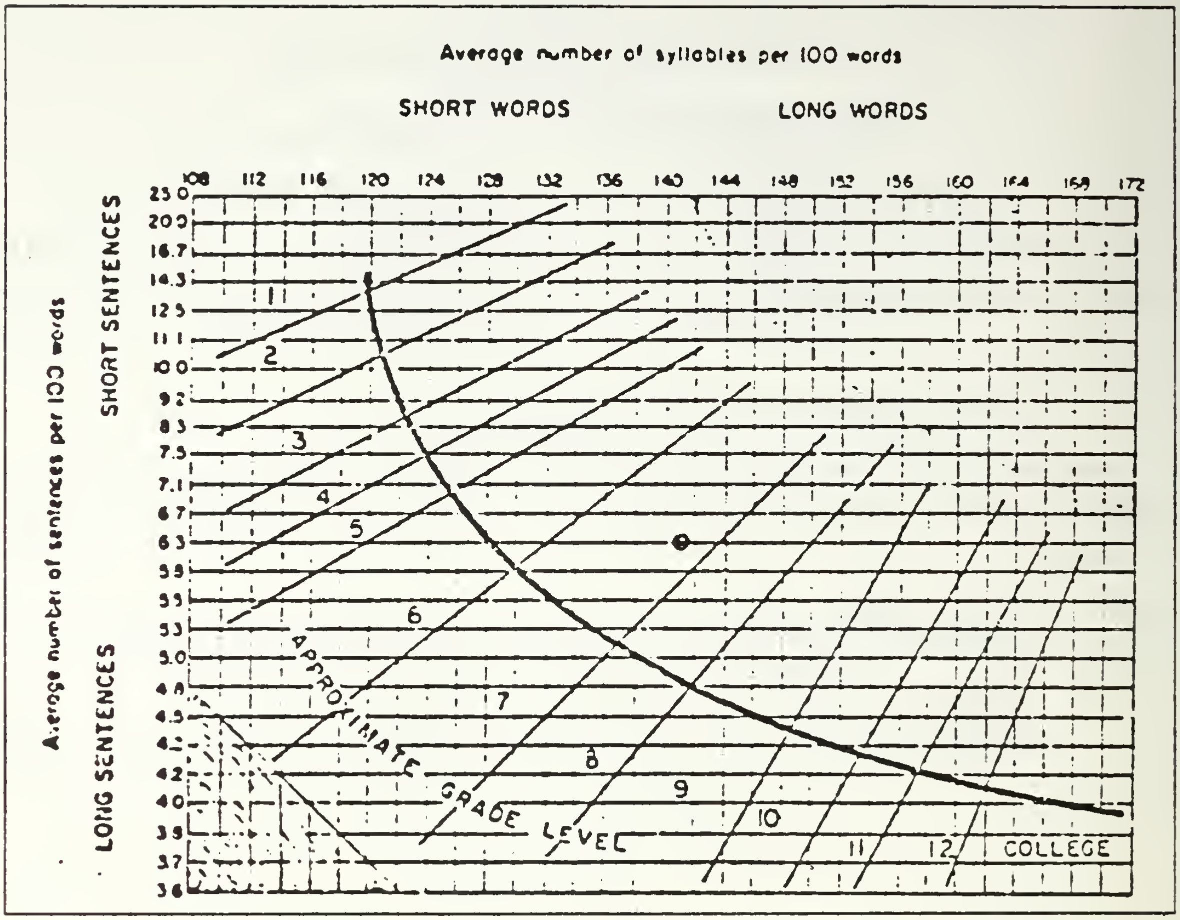

Figure E.1 Fry Readability Graph.

$$L = W / S \qquad \text{(eqn E.6)}$$

5) Count the number of polysyllable words in the sample (PW).

6) Compute the percentage of polysyllable words in the sample (P):

$$P = (PW / W) \times 100 \qquad \text{(eqn E.7)}$$

7) Compute the Gunning Fog Index (G):

$$G = (.4) \times (L + P) \qquad \text{(eqn E.8)}$$

8) The equivalent grade levels corresponding to the Gunning Fog Indices are listed in Table 26.

TABLE 26

GUNNING FOG INDEX RATINGS

Fog Index Rating (G)	Equivalent Grade Level
17	College graduate
16	College senior
15	College junior
14	College sophomore
13	College freshman
12	High School senior
11	High School junior
10	High School sophomore
9	High School freshman
8	Eighth grade
7	Seventh grade
6	Sixth grade

4. RESULTS

Using the Dale-Chall method, Appendix A had a raw score of 6.7744 for an equivalent grade level of 7-8th grade. The results using the Fry Readability Graph and assuming College equals the 13th grade, Appendix A had an initial equivalent grade level of 12.5. Finally, with the Gunning Fog Index of Readability, Appendix A had an initial index of 13.17 for an equivalent grade level of a college freshman (13th grade).

APPENDIX F

INPUT DATA

99.9 - Placeholder (no data)
ROW - Method of Instructional Delivery
COLUMN - Individual Test Score

1. All Test Scores

Initial Test Results

12.0	14.0	15.0	26.5	15.5	21.5	16.5	34.0	11.5	18.0	99.9	99.9
32.0	23.0	25.5	11.5	29.0	17.0	18.5	18.0	16.0	21.0	99.9	99.9
26.0	17.5	26.0	23.0	23.5	16.0	14.0	26.5	99.9	99.9	99.9	99.9
19.5	19.0	11.0	16.0	16.0	18.5	13.0	18.0	11.0	4.0	12.0	6.0
19.0	10.0	20.0	26.0	37.0	37.5	30.0	23.5	22.5	18.0	99.9	99.9
25.0	33.0	32.5	15.0	26.0	27.0	24.0	14.5	10.0	38.0	99.9	99.9
31.5	19.0	19.0	27.5	24.5	19.0	25.0	20.5	27.0	19.0	99.9	99.9

Retention Test Results

19.0	15.5	21.5	22.0	28.0	22.0	14.0	27.0	13.0	20.5	99.9	99.9
26.5	14.0	23.0	22.0	24.0	23.5	17.5	18.0	25.0	19.5	99.9	99.9
21.0	23.0	25.5	16.0	20.5	20.0	25.0	26.0	99.9	99.9	99.9	99.9
19.0	15.5	14.5	20.5	15.0	21.0	18.0	24.0	10.0	13.0	19.0	17.0
17.0	23.0	21.0	22.5	29.5	32.0	23.5	25.5	26.0	23.0	99.9	99.9
27.0	32.0	19.0	11.0	23.0	23.0	22.0	14.5	20.0	27.5	99.9	99.9
28.5	24.0	13.0	23.5	22.0	13.0	28.5	22.0	24.0	14.0	99.9	99.9

Old Question Results

13.0	14.5	18.5	15.0	18.5	16.5	10.0	19.5	11.0	14.5	99.9	99.9
17.0	14.0	17.0	19.0	19.0	15.0	14.5	16.0	19.0	16.0	99.9	99.9
17.0	17.0	17.0	14.0	15.0	16.0	19.0	17.0	99.9	99.9	99.9	99.9
16.5	12.0	12.0	15.0	13.0	16.0	16.0	18.0	8.0	11.0	15.0	15.0
13.0	16.0	15.0	19.0	18.0	21.0	18.0	17.0	19.0	14.0	99.9	99.9
18.0	20.0	16.0	11.0	20.0	16.5	17.0	11.0	14.0	22.0	99.9	99.9
19.5	18.0	11.0	15.5	19.0	13.0	20.5	17.0	17.5	11.0	99.9	99.9

New Question Results

6.0	1.0	3.0	7.0	9.5	5.5	4.0	7.5	2.0	6.0	99.9	99.9
9.5	0.0	6.0	3.0	5.0	8.5	3.0	2.0	6.0	3.5	99.9	99.9
4.0	6.0	8.5	2.0	5.5	4.0	6.0	9.0	99.9	99.9	99.9	99.9
2.5	3.5	2.5	5.5	2.0	5.0	2.0	6.0	2.0	2.0	4.0	2.0
4.0	7.0	6.0	3.5	11.5	11.0	5.5	8.5	7.0	9.0	99.9	99.9
9.0	12.0	3.0	0.0	3.0	6.5	5.0	3.5	6.0	5.5	99.9	99.9
9.0	6.0	2.0	8.0	3.0	0.0	8.0	5.0	6.5	3.0	99.9	99.9

2. Equal Group Size Test Scores

Initial Test Results

12.0	14.0	26.5	15.5	21.5	16.5	11.5	18.0
32.0	23.0	25.5	11.5	17.0	18.0	16.0	21.0
26.0	17.5	26.0	23.0	23.5	16.0	14.0	26.5
19.0	16.0	18.5	13.0	11.0	4.0	12.0	6.0
19.0	20.0	26.0	37.0	37.5	30.0	22.5	18.0
25.0	33.0	32.5	26.0	27.0	24.0	14.5	38.0
31.5	19.0	19.0	27.5	24.5	20.5	27.0	19.0

Retention Test Results

19.0	15.5	22.0	28.0	22.0	14.0	13.0	20.5
26.5	14.0	23.0	22.0	23.5	18.0	25.0	19.5
21.0	23.0	25.5	16.0	20.5	20.0	25.0	26.0
15.5	20.5	21.0	18.0	10.0	13.0	19.0	17.0
17.0	21.0	22.5	29.5	32.0	23.5	26.0	23.0
27.0	32.0	19.0	23.0	23.0	22.0	14.5	27.5
28.5	24.0	13.0	23.5	22.0	22.0	24.0	14.0

Old Question Results

13.0	14.5	15.0	18.5	16.5	10.0	11.0	14.5
17.0	14.0	17.0	19.0	15.0	16.0	19.0	16.0
17.0	17.0	17.0	14.0	15.0	16.0	19.0	17.0
12.0	15.0	16.0	16.0	8.0	11.0	15.0	15.0
13.0	15.0	19.0	18.0	21.0	18.0	19.0	14.0
18.0	20.0	16.0	20.0	16.5	17.0	11.0	22.0
19.5	18.0	11.0	15.5	19.0	17.0	17.5	11.0

New Question Results

6.0	1.0	7.0	9.5	5.5	4.0	2.0	6.0
9.5	0.0	6.0	3.0	8.5	2.0	6.0	3.5
4.0	6.0	8.5	2.0	5.5	4.0	6.0	9.0
3.5	5.5	5.0	2.0	2.0	2.0	4.0	2.0
4.0	6.0	3.5	11.5	11.0	5.5	7.0	9.0
9.0	12.0	3.0	3.0	6.5	5.0	3.5	5.5
9.0	6.0	2.0	8.0	3.0	5.0	6.5	3.0

3. Background Questionaire Results

Grade Point Averages

1.65	3.00	2.80	3.40	2.60	3.00	2.80	3.00	3.80	2.90	99.90	99.90
2.70	2.75	3.40	3.40	2.40	3.20	3.40	2.70	1.80	3.50	99.90	99.90
2.75	2.80	2.00	2.00	3.00	2.90	3.20	3.60	99.90	99.90	99.90	99.90
3.80	3.00	2.50	4.00	2.00	3.00	2.75	2.98	3.00	2.00	2.50	2.00
3.00	2.50	3.00	2.00	2.80	3.33	3.50	2.50	3.00	3.00	99.90	99.90
3.00	1.20	3.00	2.50	2.80	3.00	2.90	2.80	2.00	3.00	99.90	99.90
3.00	2.70	2.80	3.00	3.63	2.80	2.50	2.50	2.50	2.80	99.90	99.90

Average Amount of Sleep

6.0	6.0	4.0	6.0	7.0	7.0	6.0	6.5	5.0	6.0	99.9	99.9
3.5	6.0	6.0	4.5	6.0	7.0	6.5	6.5	6.0	4.0	99.9	99.9
5.0	5.0	6.0	4.0	6.0	4.0	6.0	5.0	99.9	99.9	99.9	99.9
4.5	8.0	5.0	6.0	5.0	5.5	5.0	7.0	4.0	6.0	5.0	5.0
5.5	6.0	8.0	5.0	7.0	3.5	6.0	6.0	7.5	6.5	99.9	99.9
5.0	5.0	7.0	5.0	6.0	5.5	6.0	5.5	6.0	6.0	99.9	99.9
6.0	5.5	5.5	6.5	5.0	4.0	6.0	4.0	5.0	4.8	99.9	99.9

Amount of Sleep Before the First Test

5.0	5.0	5.0	3.0	5.0	6.5	5.0	5.0	5.0	6.0	99.9	99.9
4.0	3.5	8.0	5.0	6.0	8.5	7.0	7.0	6.0	4.0	99.9	99.9
4.5	6.0	5.0	4.0	4.0	4.0	6.0	5.0	99.9	99.9	99.9	99.9
2.0	7.0	5.0	4.0	4.0	4.5	6.0	5.5	4.0	7.0	4.5	5.5
3.0	5.0	7.0	8.0	4.5	3.0	6.5	6.0	7.0	6.0	99.9	99.9
5.0	5.0	6.5	6.0	5.5	5.0	5.5	3.0	5.0	4.0	99.9	99.9
5.0	5.0	5.5	8.0	3.5	4.0	6.5	4.0	6.0	5.0	99.9	99.9

Amount of Sleep Before the Second Test

6.0	14.0	6.0	7.0	5.6	7.0	2.5	4.5	0.0	3.0	99.9	99.9
9.0	4.5	6.0	8.5	10.0	4.0	6.5	8.0	9.0	6.0	99.9	99.9
3.0	5.0	5.5	5.5	4.5	2.0	5.0	4.5	99.9	99.9	99.9	99.9
4.5	6.0	5.0	4.0	4.0	6.0	6.0	5.0	4.5	5.0	4.5	5.0
10.0	2.0	7.5	8.0	6.0	5.0	5.0	7.0	7.0	5.5	99.9	99.9
3.5	9.0	5.0	5.0	4.0	6.0	7.0	5.0	9.0	8.0	99.9	99.9
5.0	6.0	5.0	5.5	5.0	4.0	6.0	5.0	6.0	5.0	99.9	99.9

Years of Schooling Received

12.0	12.0	14.0	12.0	12.0	12.0	11.0	16.0	12.0	12.0	99.9	99.9
12.0	12.0	12.0	12.0	16.0	16.0	12.0	16.0	11.0	12.0	99.9	99.9
12.0	13.0	12.0	16.0	12.0	12.0	15.0	13.0	99.9	99.9	99.9	99.9
10.5	12.0	12.0	13.5	12.0	12.0	12.0	14.0	12.0	13.0	12.0	12.0
12.0	12.0	13.0	11.8	12.0	12.0	12.0	12.0	13.0	12.0	99.9	99.9
12.0	13.0	12.0	12.0	12.0	12.0	12.5	12.0	13.0	12.0	99.9	99.9
12.0	12.0	12.0	12.0	12.0	12.0	12.0	13.0	12.0	15.0	99.9	99.9

Amount of Time Since Last Schooling

0.58	1.08	1.00	3.00	1.00	1.08	1.08	0.50	3.08	1.00	99.90	99.90
2.08	6.00	2.08	8.00	1.25	2.00	1.50	1.50	2.00	1.00	99.90	99.90
2.00	0.75	4.08	0.50	4.08	3.08	0.50	1.00	99.90	99.90	99.90	99.90
0.25	1.00	1.00	1.00	1.00	1.00	1.25	3.00	1.00	0.08	1.00	1.00
1.00	3.00	0.50	1.25	4.00	1.50	1.00	7.00	1.25	4.00	99.90	99.90
3.00	2.00	3.00	2.00	1.00	3.00	1.00	1.08	4.08	10.00	99.90	99.90
1.17	2.00	2.00	1.00	1.00	0.08	1.17	2.50	4.08	0.50	99.90	99.90

Number of Books Read in the Last Year

1.0	0.0	12.0	67.0	250.0	3.0	3.0	67.0	30.0	6.0	99.9	99.9
4.0	1.0	0.0	4.0	3.0	20.0	0.0	5.0	250.0	0.0	99.9	99.9
3.0	2.0	10.0	3.0	1.0	4.0	40.0	0.0	99.9	99.9	99.9	99.9
50.0	3.0	0.0	3.0	50.0	5.0	20.0	3.0	1.0	12.0	4.0	3.0
17.0	400.0	0.0	3.0	7.0	25.0	0.0	10.0	30.0	4.0	99.9	99.9
15.0	2.0	3.0	10.0	3.0	0.0	4.0	3.0	0.0	0.0	99.9	99.9
20.0	15.0	0.0	1.0	7.0	3.0	12.0	5.0	5.0	10.0	99.9	99.9

```
*                              APPENDIX G
*
*                           COMPUTER PROGRAMS
*
***********           CHI-SQUARE Goodness of Fit Test            ***********
*
*     After transforming the input data (subtracting the mean and then
*dividing this whole quantity by the standard deviation), this program
*uses a Chi-square Goodness of Fit Test to see if the data is normally
*distributed, N(0,1).  The output is the critical value of the test
*(i.e., the minimum level of significance required to reject a normal
*distribution).
*
*VARIABLES:
*  CHI(i) - values of the appropriate chi-square random variable
*  D(i);D2(i) - used in computing the test statistic
*  DASH - "-"; a dash, used for output
*  E(i) - expected value of the ith interval
*  F(i) - counter for the number of data points in the ith interval
*  MU - overall grand mean of the data
*  NDATA - total number of data points
*  NTEST(i) - number of scores in the ith group
*  P(i) - percentiles of the chi-square random variable
*  PZ(i) - N(0,1) probabilities for the ith interval
*  RATIO - ratio used to determine the critical level
*  SCR(i,j) - test score of the jth individual in the ith group
*  SIGLVL - the critical level of the test
*  SIGMA - average of the methods' standard deviations
*  TS - test statistic
*  UN - "_"; the underline symbol, used for output
*  Z(i,j) - transformed test scores
*  I,J,K1,K2,K3,M -counters
*
      REAL MU
      CHARACTER*1 UN, DASH
      DIMENSION SCR(6,12), NTEST(6), Z(6,12), F(12), E(12), PZ(12)
      DIMENSION D(12), D2(12), CHI(13), P(13)
      DATA DASH/'-'/, UN/'_'/, MU/2.82/, SIGMA/.556/
      DATA P/.005,.01,.025,.05,.1,.25,.5,.75,.9,.95,.975,.99,.995/
      DATA CHI/2.6,3.05,3.82,4.57,5.58,7.58,10.3,13.7,17.3,19.7,21.9,24.
     C7,26.8/
      DATA PZ/.0062,.0165,.0441,.0919,.1498,.1915,.1915,.1498,.0919,.044
     C1,.0165,.0062/
*
* Initialization steps
*
      NDATA=0
      TS=0.0
      DO 10 I=1,6
         NTEST(I)=0
   10 CONTINUE
      DO 20 J=1,12
         F(J)=0.0
   20 CONTINUE
      DO 110 M=1,6
         READ(5,100) SCR(M,1),SCR(M,2),SCR(M,3),SCR(M,4),SCR(M,5),SCR(M,
     C6),SCR(M,7),SCR(M,8),SCR(M,9),SCR(M,10),SCR(M,11),SCR(M,12)
  100    FORMAT(12F5.1)
  110 CONTINUE
*
* Transforms the input data
*
      DO 130 M=1,6
         DO 120 I=1,12
            IF(SCR(M,I).EQ.99.9) GOTO 120
            NTEST(M)=NTEST(M)+1
            Z(M,NTEST(M))=(SCR(M,I)-MU)/SIGMA
  120    CONTINUE
         NDATA=NDATA+NTEST(M)
  130 CONTINUE
```

```
*
* Counts the number of data points in each interval
*
      DO 145 M=1,6
         DO 140 I=1,NTEST(M)
            IF(Z(M,I).LE.-2.5) THEN
               F(1)=F(1)+1.0
            ELSE IF(Z(M,I).LE.-2.0) THEN
               F(2)=F(2)+1.0
            ELSE IF(Z(M,I).LE.-1.5) THEN
               F(3)=F(3)+1.0
            ELSE IF(Z(M,I).LE.-1.0) THEN
               F(4)=F(4)+1.0
            ELSE IF(Z(M,I).LE.-0.5) THEN
               F(5)=F(5)+1.0
            ELSE IF(Z(M,I).LE.0.0) THEN
               F(6)=F(6)+1.0
            ELSE IF(Z(M,I).LE.0.5) THEN
               F(7)=F(7)+1.0
            ELSE IF(Z(M,I).LE.1.0) THEN
               F(8)=F(8)+1.0
            ELSE IF(Z(M,I).LE.1.5) THEN
               F(9)=F(9)+1.0
            ELSE IF(Z(M,I).LE.2.0) THEN
               F(10)=F(10)+1.0
            ELSE IF(Z(M,I).LE.2.5) THEN
               F(11)=F(11)+1.0
            ELSE
               F(12)=F(12)+1.0
            END IF
  140    CONTINUE
  145 CONTINUE
*
* Computes each interval's expected value
*
      DO 150 K1=1,12
         E(K1)=PZ(K1)*(REAL(NDATA))
  150 CONTINUE
*
* Computes the chi-square test statistic
*
      DO 160 K2=1,12
         D(K2)=F(K2)-E(K2)
         D2(K2)=(ABS(D(K2)))**2
         TS=TS+D2(K2)/E(K2)
  160 CONTINUE
*
* Computes the critcal level
*
      DO 170 K3=2,13
         IF(TS.LT.CHI(K3)) THEN
            RATIO=(TS-CHI(K3-1))/(CHI(K3)-CHI(K3-1))
            SIGLVL=1-(P(K3-1)+RATIO*(P(K3)-P(K3-1)))
            GOTO 180
          ELSE
         END IF
  170 CONTINUE
      IF(TS.LT.CHI(1)) THEN
         SIGLVL=.995
        ELSE
         SIGLVL=.005
      END IF
*
* Output section
*
  180 WRITE(7,210)
  210 FORMAT('1'/'0'/16X,'-----CHI-SQUARE Goodness of Fit TEST-----',
     1/'0'/24X,'to a NORMAL Distribution'/2('0'/),
     2'0',4X,'INPUT DATA',5X,'MEAN',6X,'STD DEV',5X,'TEST STATISTIC',
     C5X,'SIG LVL')
      WRITE(7,270) (UN,IC=1,10),(UN,JC=1,5),(UN,KC=1,7),(UN,LC=1,14),
     C(UN,MC=1,7)
```

```
  270 FORMAT('+',4X,10A1,5X,5A1,5X,7A1,5X,14A1,5X,7A1)
      WRITE(7,280) MU,SIGMA,TS,SIGLVL
  280 FORMAT('0',4X,'GPA',12X,F5.2,6X,F5.3,8X,F8.4,9X,F7.5)
      STOP
      END
*
*
*
*
*
*******      ANOVA and Individual Degrees of Freedom Tests      ********
*
*     This program computes the critical levels (the minimum levels of
*significance required to reject the null hypotheses of equal means)
* in a one-way Analysis of Variance (ANOVA) test and an ANOVA test with
*individual degrees of freedom.
*
*VARIABLES:
*  AMGPOP - sum of the squared total scores divided by the # of data
*  COLUMN(i) - name of a comparison for individual degrees of freedom
*  D(i) - D value for the ith degree of freedom
*  DASH - "-"; a dash, used for output
*  DFA - among population degrees of freedom (k-1)
*  DFE - error degrees of freedom (n-k)
*  FRAT - ratio used to compute individual d.f. critical value
*  FRATIO - ratio used to compute ANOVA critical value
*  FSTAR - ANOVA test statistic
*  FTEST(i) - ith degree of freedom test statistic
*  Fxy - F table values for (x,y) degrees of freedom
*  IDFA - integer among population degrees of freedom
*  IDFE - integer error degrees of freedom
*  IDFT - integer total degrees of freedom
*  M1 - method 1
*  M2 - method 2
*  MSA - among population mean square
*  MSE - error mean square
*  NTEST(m) - number of tests taken in the mth group
*  PRBF(i) - percentiles of the tabled F values
*  PRBS - used in computing the ANOVA critical value
*  RATIO - used in computing the ANOVA critical value
*  RGHI(m) - highest score in method m
*  RGLO(m) - lowest score in method m
*  SAMPSD(m) - sample standard deviation of method m
*  SCR(m,j) - jth individual test score in method m
*  SGLVL(i) - critical level for the ith degree of freedom
*  SIGLVL - ANOVA critical level
*  SMPVAR(m) - sample variance of method m
*  SQRDEV(m) - sum of the squared deviations for method m
*  SSA - among population sum of squares
*  SSE - error sum of squares
*  SST - total sum of squares
*  SYIJSQ - sum of the squared test scores
*  TOTNUM - total number of tests
*  TOTSCR(m) - total of all test scores in method m
*  TOTSUM - total sum of all test scores
*  UN - "_"; the underline symbol, used for output
*  WSQR(i) - W-squared value for the ith degree of freedom
*  XBAR(m) - sample mean for method m
*  Z(i) - Z values for the ith degree of freedom
*  I,J,J1,KR,M - counters
*
      REAL MSA,MSE
      CHARACTER*1 UN,DASH
      CHARACTER*8 COLUMN
      DIMENSION SCR(7,8), NTEST(7), TOTSCR(7), XBAR(7), SQRDEV(7)
      DIMENSION SMPVAR(7), SAMPSD(7), RGHI(7), RGLO(7), Z(2:7)
      DIMENSION F649(11), F149(11), COLUMN(2:7), D(2:7), WSQR(2:7)
      DIMENSION FTEST(2:7), SGLVL(2:7), PRBF(11)
      DATA PRBF/.001,.01,.05,.10,.25,.5,.75,.9,.95,.99,.999/
      DATA F649/.061,.141,.27,.36,.57,.9,1.36,1.9,2.3,3.2,4.55/
      DATA F149/.0000016,.00016,.004,.016,.103,.46,1.36,2.8,4.04,7.2,12.
     C29/
```

```
      DATA COLUMN/'4V123567','123V567 ','12 V 3  ','56 V 7  ',' 1 V 2  '
     C,' 5 V 6  '/
      DATA UN/'_'/, DASH/'-'/, D/336.0,48.0,48.0,48.0,16.0,16.0/
*
* Initialization steps
*
      DO 10 I=1,7
         NTEST(I)=0
         TOTSCR(I)=0.0
         SQRDEV(I)=0.0
         RGHI(I)=0.0
         RGLO(I)=100.0
   10 CONTINUE
      DO 20 L=2,7
         Z(L)=0.0
   20 CONTINUE
      SYIJSQ=0.0
      TOTSUM=0.0
      AMGPOP=0.0
      TOTNUM=56.0
      DFA=6.0
      DFE=49.0
*
* Data input
*
      DO 120 M=1,7
            READ(5,100) SCR(M,1), SCR(M,2), SCR(M,3), SCR(M,4),
     CSCR(M,5), SCR(M,6), SCR(M,7), SCR(M,8)
  100       FORMAT(8F5.1)
  120 CONTINUE
*
* One-way ANOVA computations
*
      DO 150 M=1,7
         DO 130 J=1,8
            NTEST(M)=NTEST(M)+1
            TOTSCR(M)=TOTSCR(M)+SCR(M,J)
            SYIJSQ=SYIJSQ+SCR(M,J)**2
            TOTSUM=TOTSUM+SCR(M,J)
            IF(SCR(M,J).GT.RGHI(M)) RGHI(M)=SCR(M,J)
            IF(SCR(M,J).LT.RGLO(M)) RGLO(M)=SCR(M,J)
  130    CONTINUE
         AMGPOP=AMGPOP+(TOTSCR(M)**2)/REAL(NTEST(M))
         XBAR(M)=TOTSCR(M)/REAL(NTEST(M))
         DO 140 J1=1,NTEST(M)
            SQRDEV(M)=SQRDEV(M)+(SCR(M,J1)-XBAR(M))**2
  140    CONTINUE
         SMPVAR(M)=SQRDEV(M)/REAL(NTEST(M)-1)
         SAMPSD(M)=(SMPVAR(M))**.5
  150 CONTINUE
*
* Output
*
      WRITE(7,153) (DASH,IC=1,5),(DASH,JC=1,5)
  153 FORMAT(22X,5A1,'NEW QUESTION RESULTS',5A1)
      WRITE(7,155)
  155 FORMAT(20X)
      WRITE(7,157)
  157 FORMAT(20X)
      WRITE(7,160)
  160 FORMAT('0',20X,'METHOD',10X,'TYPE OF TRAINING')
      WRITE(7,165) (UN,IC=1,6),(UN,JC=1,16)
  165 FORMAT('+',20X,6A1,10X,16A1)
      WRITE(7,170)
  170 FORMAT(24X,'1',15X,'LECTURE')
      WRITE(7,175)
  175 FORMAT(24X,'2',15X,'VIDEO')
      WRITE(7,180)
  180 FORMAT(24X,'3',15X,'READING')
      WRITE(7,183)
  183 FORMAT(24X,'4',15X,'CONTROL')
      WRITE(7,185)
```

```
  185 FORMAT(24X,'5',15X,'AUDIO 1.00')
      WRITE(7,190)
  190 FORMAT(24X,'6',15X,'AUDIO 1.25')
      WRITE(7,195)
  195 FORMAT(24X,'7',15X,'AUDIO 1.50')
      WRITE(7,200)
  200 FORMAT('0',20X)
*
* Data analysis output
*
      WRITE(7,210) (DASH,IC=1,12),(DASH,JC=1,13),(DASH,KC=1,4),(DASH,LC=
     C1,4)
  210 FORMAT(21X,12A1,'SAMPLE',13A1,9X,4A1,'RANGE',4A1)
      WRITE(7,220)
  220 FORMAT(20X)
      WRITE(7,230)
  230 FORMAT(22X,'MEAN',6X,'VARIANCE',5X,'STD DEV',9X,'HIGH',5X,'LOW')
      WRITE(7,240) (UN,IC=1,4),(UN,JC=1,8),(UN,KC=1,7),(UN,LC=1,4),(UN,M
     CC=1,4)
  240 FORMAT('+',21X,4A1,6X,8A1,5X,7A1,9X,4A1,5X,4A1)
      WRITE(7,250)
  250 FORMAT(20X)
      DO 270 M=1,7
         WRITE(7,260) M, XBAR(M), SMPVAR(M), SAMPSD(M), RGHI(M),RGLO(M)
  260    FORMAT('    METHOD',I2,10X,F6.3,4X,F9.3,5X,F7.3,8X,F5.1,5X,F4.1)
  270 CONTINUE
      WRITE(7,273)
  273 FORMAT(20X)
      WRITE(7,276)
  276 FORMAT(20X)
*
* ANOVA table computations and output
*
      SST=SYIJSQ-(TOTSUM**2)/TOTNUM
      SSA=AMGPOP-(TOTSUM**2)/TOTNUM
      SSE=SST-SSA
      MSA=SSA/DFA
      MSE=SSE/DFE
      FSTAR=MSA/MSE
      DO 575 KR=2,11
         IF(FSTAR.LT.F649(KR)) THEN
            FRATIO=(FSTAR-F649(KR-1))/(F649(KR)-F649(KR-1))
            PRBS=PRBF(KR-1)+FRATIO*(PRBF(KR)-PRBF(KR-1))
            SIGLVL=1.0-PRBS
            GOTO 578
          ELSE
         END IF
  575 CONTINUE
      IF(FSTAR.LT.F649(1)) THEN
         SIGLVL=.999
        ELSE
         SIGLVL=.001
      END IF
  578 WRITE(7,580)(DASH,IC=1,5),(DASH,JC=1,5)
  580 FORMAT(26X,5A1,'ANOVA TABLE',5A1)
      WRITE(7,583)
  583 FORMAT('0',20X)
      WRITE(7,585)
  585 FORMAT(6X,'SOURCE',9X,'SS',8X,'DF',9X,'MS',10X,'FSTAT',8X,'SIGLVL'
     C)
      WRITE(7,590) (UN,IC=1,6),(UN,JC=1,9),(UN,KC=1,2),(UN,LC=1,9),(UN,M
     CC=1,9),(UN,NC=1,8)
  590 FORMAT('+',5X,6A1,5X,9A1,5X,2A1,5X,9A1,5X,9A1,5X,8A1)
      IDFA=INT(DFA)
      IDFE=INT(DFE)
      IDFT=IDFA+IDFE
      WRITE(7,592) SSA,IDFA,MSA,FSTAR,SIGLVL
  592 FORMAT(6X,'METHOD',5X,F9.3,5X,I2,5X,F9.3,5X,F9.5,5X,F8.5)
      WRITE(7,595) SSE,IDFE,MSE
  595 FORMAT(6X,'ERROR',6X,F9.3,5X,I2,5X,F9.3)
      WRITE(7,600) (UN,IC=1,68)
  600 FORMAT('+',5X,68A1)
```

```
      WRITE(7,610) SST,IDFT
  610 FORMAT(6X,'TOTAL',6X,F9.3,5X,I2)
      WRITE(7,620)
  620 FORMAT('0',20X)
*
* Individual degree of freedom ANOVA calculations
*
      DO 630 I=1,8
         Z(2)=Z(2)-SCR(1,I)-SCR(2,I)-SCR(3,I)+6*SCR(4,I)-SCR(5,I)-SCR(6,
     CI)-SCR(7,I)
  630 CONTINUE
      DO 640 I=1,8
         Z(3)=Z(3)+SCR(1,I)+SCR(2,I)+SCR(3,I)-SCR(5,I)-SCR(6,I)-SCR(7,I)
  640 CONTINUE
      DO 650 I=1,8
         Z(4)=Z(4)+SCR(1,I)+SCR(2,I)-2*SCR(3,I)
  650 CONTINUE
      DO 660 I=1,8
         Z(5)=Z(5)+SCR(5,I)+SCR(6,I)-2*SCR(7,I)
  660 CONTINUE
      DO 663 I=1,8
         Z(6)=Z(6)+SCR(1,I)-SCR(2,I)
  663 CONTINUE
      DO 667 I=1,8
         Z(7)=Z(7)+SCR(5,I)-SCR(6,I)
  667 CONTINUE
      DO 680 I=2,7
         WSQR(I)=(Z(I)**2)/D(I)
         FTEST(I)=WSQR(I)/MSE
  680 CONTINUE
      WRITE(7,690)(DASH,IC=1,5),(DASH,JC=1,5)
  690 FORMAT(17X,5A1,'INDIVIDUAL DEGREES OF FREEDOM',5A1)
      WRITE(7,700)
  700 FORMAT('0',20X)
      WRITE(7,710)
  710 FORMAT(6X,'SOURCE',9X,'SS',8X,'DF',9X,'MS',10X,'FSTAT',8X,'SIGLVL'
     C)
      WRITE(7,720) (UN,IC=1,7),(UN,JC=1,9),(UN,KC=1,2),(UN,LC=1,9),(UN,M
     CC=1,9),(UN,NC=1,8)
  720 FORMAT('+',5X,7A1,4X,9A1,5X,2A1,5X,9A1,5X,9A1,5X,8A1)
*
* Individual degree of freedom critical level computations
*
      DO 760 I=2,7
         DO 730 KR=2,11
            IF(FTEST(I).LT.F149(KR)) THEN
               FRAT=(FTEST(I)-F149(KR-1))/(F149(KR)-F149(KR-1))
               PRBI=PRBF(KR-1)+FRAT*(PRBF(KR)-PRBF(KR-1))
               SGLVL(I)=1.0-PRBI
               GOTO 740
             ELSE
            END IF
  730    CONTINUE
         IF(FTEST(I).LT.F149(1)) THEN
            SGLVL(I)=.999
          ELSE
            SGLVL(I)=.001
         END IF
  740    WRITE(7,750) COLUMN(I),WSQR(I),WSQR(I),FTEST(I),SGLVL(I)
  750    FORMAT(6X,A7,4X,F9.3,5X,' 1',5X,F9.3,5X,F9.5,5X,F8.5)
  760 CONTINUE
      WRITE(7,770) SSE,IDFE,MSE
  770 FORMAT(7X,'ERROR',5X,F9.3,5X,I2,5X,F9.3)
      WRITE(7,780) (UN,IC=1,68)
  780 FORMAT('+',5X,68A1)
      WRITE(7,790) SST,IDFT
  790 FORMAT(6X,'TOTAL',6X,F9.3,5X,I2)
      STOP
      END
*
*
*
```

```
*
*
***************          ANOVA and Two Sample Tests          ***************
*
*     This program computes the critical levels (the minimum levels of
*significance required to reject the test's null hypothesis) from a
*one-way Analysis of Variance (ANOVA) test and the associated two
*sample tests.  Before the t-tests are performed, an F-test of equal
*variances is done and if the critical level is less than .05 (i.e.,
*unequal variances), a Behrens-Fisher-Welch test is performed instead
*of a t-test.
*
*VARIABLES:
*  ALEQMN(m1,m2) - critical value for testing (mu1 = m2)
*  ALGTMN(m1,m2) - critical value for testing (mu1 >= m2)
*  ALLTMN(m1,m2) - critical value for testing (mu1 <= m2)
*  AMGPOP - sum of the squared total scores divided by the # of data
*  D(m1,m2) - Welch test degrees of freedom for method m1 and method m2
*  DASH - "-"; a dash, used for output
*  DF(m1,m2) - t-test degrees of freedom for method m1 and method m2
*  DFA - among population degrees of freedom (k-1)
*  DFE - error degrees of freedom (n-k)
*  DFDENR - right side of D(m1,m2)'s denominator
*  DFDENL - left side of D(m1,m2)'s denominator
*  DFNUM - D(m1,m2)'s numerator
*  FRATIO - ratio used to compute ANOVA critical value
*  FSTAR - ANOVA test statistic
*  FSTAT(m1,m2) - test statistic in F-test of method m1 and method m2
*  Fxy - F table values for (x,y) degrees of freedom
*  IDFA - integer among population degrees of freedom
*  IDFE - integer error degrees of freedom
*  IDFT - integer total degrees of freedom
*  M1 - method 1
*  M2 - method 2
*  MSA - among population mean square
*  MSE - error mean square
*  NTEST(m) - number of tests taken in the mth group
*  POLDEN - denominator of the t-test statistic
*  POLNM2 - part of the numerator of the t-test statistic
*  POLNUM - part of the numerator of the t-test statistic
*  POLVAR(m1,m2) - pooled variance of method m1 and method m2
*  PRBF(i) - percentiles of the tabled F values
*  PRBT(i) - percentiles of the tabled t values
*  PRBS - used in computing the ANOVA critical value
*  PRBT1 - used in computing the t-test critical value
*  RATIO - used in computing the ANOVA critical value
*  RGHI(m) - highest score in method m
*  RGLO(m) - lowest score in method m
*  SAMPSD(m) - sample standard deviation of method m
*  SCORE(m,j) - jth individual test score in method m
*  SIGLVL - ANOVA critical level
*  SMPVAR(m) - sample variance of method m
*  SQRDEV(m) - sum of the squared deviations for method m
*  SSA - among population sum of squares
*  SSE - error sum of squares
*  SST - total sum of squares
*  SYIJSQ - sum of the squared test scores
*  TOTNUM - total number of tests
*  TOTSCR(m) - total of all test scores in method m
*  TOTSUM - total sum of all test scores
*  TSTAT(m1,m2) - t-test statistic for method m1 and method m2
*  TWEL - t values for interpolated degrees of freedom
*  Tx - t table values for x degrees of freedom
*  UDEN - denominator for USTAT(m1,m2) of the Welch test
*  UN - "_"; the underline symbol, used for output
*  UNUM - numerator for USTAT(m1,m2) of the Welch test
*  USTAT(m1,m2) - test statistic for the Welch test
*  XBAR(m) - sample mean for method m
*  I,J,K,KR,KT,L,M,M1,M2,N - counters
*
***Dummy variables used in the subroutines
***  ALPHEQ   used as   ALEQMN(m1,m2)
```

```
***  ALPHGT   used as   ALGTMN(m1,m2)
***  ALPHLT   used as   ALLTMN(m1,m2)
***  DM12     used as   D(m1,m2)
***  FM1M2    used as   FSTAT(m1,m2)
***  FMM12    is  the   absolute value of FM1M2
***  NM1      used as   NTEST(m1)
***  NM2      used as   NTEST(m2)
***  SVARM1   used as   SMPVAR(m1)
***  SVARM2   used as   SMPVAR(m2)
***  TA       used as   Tx
***  TB       used as   Tx
***  TM1M2    used as   TSTAT(m1,m2)
***  XM1      used as   XBAR(m1)
***  XM2      used as   XBAR(m2)
***  XX       used as   Tx or Fxy
***  YY       used as   FD1D2 or T
*
*Variables used just in the subroutines
*  FHI - used in critical level computations
*  FLO - used in critical level computations
*  FRCTN - fractional part of the Welch degree of freedom
*  JDFINT - integer portion of the Welch degree of freedom
*  RATIO1 - used in critical level computations
*  RATIO2 - used in critical level computations
*
      INTEGER DF
      REAL MSA,MSE
      CHARACTER*1 UN,DASH
      DIMENSION SCORE(7,12), NTEST(7), TOTSCR(7), XBAR(7), SQRDEV(7)
      DIMENSION SMPVAR(7), SAMPSD(7), POLVAR(7,7), TSTAT(7,7), T(13)
      DIMENSION FSTAT(7,7), PRBF(11), PRBT(13), T20(13), F663(11)
      DIMENSION T11(13), T12(13), T13(13), T14(13), T16(13), T18(13)
      DIMENSION F79(11), F711(11), F97(11), F99(11), F911(11),F117(11)
      DIMENSION ALEQMN(7,7), ALGTMN(7,7), ALLTMN(7,7), USTAT(7,7)
      DIMENSION D(7,7), RGHI(7), RGLO(7), DF(7,7), F119(11), FD1D2(11)
      DIMENSION TWEL(13)
      DATA PRBF/.001,.01,.05,.10,.25,.5,.75,.9,.95,.99,.999/
      DATA PRBT/.55,.6,.65,.7,.75,.8,.85,.9,.95,.975,.99,.995,.9995/
      DATA T11/.13,.26,.396,.54,.697,.88,1.09,1.36,1.8,2.2,2.7,3.1,4.4/
      DATA T12/.13,.26,.395,.54,.695,.87,1.08,1.36,1.8,2.2,2.7,3.1,4.3/
      DATA T13/.13,.26,.394,.54,.694,.87,1.08,1.35,1.8,2.2,2.7,3.0,4.2/
      DATA T14/.13,.26,.393,.54,.692,.87,1.08,1.34,1.8,2.1,2.6,3.0,4.1/
      DATA T16/.13,.26,.392,.54,.690,.87,1.07,1.34,1.8,2.1,2.6,2.9,4.0/
      DATA T18/.13,.26,.392,.53,.688,.86,1.07,1.33,1.7,2.1,2.6,2.9,3.9/
      DATA T20/.13,.26,.391,.53,.687,.86,1.06,1.32,1.7,2.1,2.5,2.8,3.9/
      DATA F79/.068,.149,.27,.367,.59,.978,1.6,2.505,3.29,5.61,10.7/
      DATA F711/.07,.15,.277,.37,.59,.96,1.54,2.34,3.01,4.886,8.66/
      DATA F97/.09,.178,.304,.399,.62,1.02,1.69,2.725,3.677,6.719,14.3/
      DATA F99/.099,.187,.315,.416,.6285,1.0,1.59,2.4,3.179,5.35,10.1/
      DATA F911/.10,.19,.32,.417,.63,.986,1.528,2.274,2.896,4.63,8.12/
      DATA F117/.115,.205,.33,.427,.649,1.037,1.687,2.69,3.61,6.54,13.9/
      DATA F119/.12,.216,.345,.44,.65,1.014,1.58,2.398,3.105,5.18,9.73/
      DATA F663/.06,.14,.267,.36,.575,.96,1.35,1.86,2.24,3.11,4.35/
      DATA UN/'_'/, DASH/'-'/
*
* Initialization steps
*
      DO 10 I=1,7
         NTEST(I)=0
         TOTSCR(I)=0.0
         SQRDEV(I)=0.0
         RGHI(I)=0.0
         RGLO(I)=100.0
   10 CONTINUE
      DO 30 L=1,7
         DO 20 N=1,7
            ALEQMN(L,N)=0.0
            ALGTMN(L,N)=0.0
            ALLTMN(L,N)=0.0
   20    CONTINUE
   30 CONTINUE
      SYIJSQ=0.0
```

```
      TOTSUM=0.0
      AMGPOP=0.0
      TOTNUM=70.0
      DFA=6.0
      DFE=63.0
      DO 40 I=1,11
         FD1D2(I)=0.0
   40 CONTINUE
      DO 50 I=1,13
         TWEL(I)=0.0
         T(I)=0.0
   50 CONTINUE
*
* Data input
*
      DO 120 M=1,7
            READ(5,100) SCORE(M,1), SCORE(M,2), SCORE(M,3), SCORE(M,4),
     CSCORE(M,5), SCORE(M,6), SCORE(M,7), SCORE(M,8), SCORE(M,9), SCORE(
     CM,10), SCORE(M,11), SCORE(M,12)
  100       FORMAT(12F5.1)
  120 CONTINUE
*
* Initial computations for the ANOVA test
*
      DO 150 M=1,7
         DO 130 J=1,12
            IF(SCORE(M,J).EQ.99.9) GOTO 130
            NTEST(M)=NTEST(M)+1
            TOTSCR(M)=TOTSCR(M)+SCORE(M,J)
            SYIJSQ=SYIJSQ+SCORE(M,J)**2
            TOTSUM=TOTSUM+SCORE(M,J)
            IF(SCORE(M,J).GT.RGHI(M)) RGHI(M)=SCORE(M,J)
            IF(SCORE(M,J).LT.RGLO(M)) RGLO(M)=SCORE(M,J)
  130    CONTINUE
         AMGPOP=AMGPOP+(TOTSCR(M)**2)/REAL(NTEST(M))
         XBAR(M)=TOTSCR(M)/REAL(NTEST(M))
         DO 140 J1=1,NTEST(M)
            SQRDEV(M)=SQRDEV(M)+(SCORE(M,J1)-XBAR(M))**2
  140    CONTINUE
         SMPVAR(M)=SQRDEV(M)/REAL(NTEST(M)-1)
         SAMPSD(M)=(SMPVAR(M))**.5
  150 CONTINUE
*
* Heading output
*
      WRITE(7,153) (DASH,IC=1,5),(DASH,JC=1,5)
  153 FORMAT(22X,5A1,'GRADE POINT AVERAGES',5A1)
      WRITE(7,155)
  155 FORMAT(20X)
      WRITE(7,157)
  157 FORMAT(20X)
*
      CALL ANOVA(SYIJSQ,TOTSUM,TOTNUM,AMGPOP,DFA,DFE,F663,PRBF,UN,DASH)
*
* Initial computations for the two sample tests
*
      DO 170 M1=1,7
         DO 160 M2=1,7
            IF(M1.EQ.M2) GOTO 160
            DF(M1,M2)=NTEST(M1)+NTEST(M2)-2
            POLVAR(M1,M2)=(SQRDEV(M1)+SQRDEV(M2))/REAL(DF(M1,M2))
            POLNUM=(XBAR(M1)-XBAR(M2))
            POLNM2=((NTEST(M1)*NTEST(M2))/REAL(NTEST(M1)+NTEST(M2)))
            POLDEN=(POLVAR(M1,M2))**.5
            TSTAT(M1,M2)=POLNUM*(POLNM2**.5)/POLDEN
            IF(DF(M1,M2).EQ.16) THEN
                 CALL TCHECK(T16,T)
              ELSE IF(DF(M1,M2).EQ.18) THEN
                 CALL TCHECK(T18,T)
              ELSE
                 CALL TCHECK(T20,T)
            END IF
```

```
          FSTAT(M1,M2)=SMPVAR(M1)/SMPVAR(M2)
          IF(NTEST(M1).EQ.7) THEN
                IF(NTEST(M2).EQ.9) THEN
                     CALL FCHECK(F79,FD1D2)
                   ELSE
                     CALL FCHECK(F711,FD1D2)
                END IF
            ELSE IF(NTEST(M1).EQ.9) THEN
                   IF(NTEST(M2).EQ.7) THEN
                       CALL FCHECK(F97,FD1D2)
                     ELSE IF(NTEST(M2).EQ.9) THEN
                       CALL FCHECK(F99,FD1D2)
                     ELSE
                       CALL FCHECK(F911,FD1D2)
                    END IF
            ELSE
                IF(NTEST(M2).EQ.7) THEN
                     CALL FCHECK(F117,FD1D2)
                   ELSE
                     CALL FCHECK(F119,FD1D2)
                 END IF
          END IF
*
*
    CALL EQUVAR(FSTAT(M1,M2),PRBF,FD1D2,TSTAT(M1,M2),T,PRBT,M1,M2,
   CXBAR(M1),XBAR(M2),SMPVAR(M1),SMPVAR(M2),NTEST(M1),NTEST(M2),ALEQMN
   C(M1,M2),ALGTMN(M1,M2),ALLTMN(M1,M2),T11,T12,T13,T14,TWEL)
*
*
 160    CONTINUE
 170 CONTINUE
*
*Data analysis output
*
    WRITE(7,180)
 180 FORMAT('1',15X)
    WRITE(7,190)
 190 FORMAT(20X)
    WRITE(7,200)
 200 FORMAT(20X)
    WRITE(7,210) (DASH,IC=1,12),(DASH,JC=1,13),(DASH,KC=1,4),(DASH,LC=
   C1,4)
 210 FORMAT(19X,12A1,'SAMPLE',13A1,9X,4A1,'RANGE',4A1)
    WRITE(7,220)
 220 FORMAT(20X)
    WRITE(7,230)
 230 FORMAT(20X,'MEAN',6X,'VARIANCE',5X,'STD DEV',9X,'HIGH',5X,'LOW')
    WRITE(7,240) (UN,IC=1,4),(UN,JC=1,8),(UN,KC=1,7),(UN,LC=1,4),(UN,M
   CC=1,4)
 240 FORMAT('+',19X,4A1,6X,8A1,5X,7A1,9X,4A1,5X,4A1)
    WRITE(7,250)
 250 FORMAT(20X)
    DO 270 M=1,7
       WRITE(7,260) M, XBAR(M), SMPVAR(M), SAMPSD(M), RGHI(M),RGLO(M)
 260    FORMAT(' METHOD',I2,10X,F6.3,4X,F9.3,5X,F7.3,8X,F5.1,5X,F4.1)
 270 CONTINUE
    WRITE(7,273)
 273 FORMAT(20X)
    WRITE(7,276)
 276 FORMAT(20X)
*
*Two sample critical level output
*
    WRITE(7,280)
 280 FORMAT(16X,'TABLE OF P-VALUES FOR REJECTING XBAR = YBAR')
    WRITE(7,290) (UN,IC=1,43)
 290 FORMAT('+',15X,43A1)
    WRITE(7,300)
 300 FORMAT(20X)
    WRITE(7,310)
 310 FORMAT(9X,' METHOD 1 METHOD 2 METHOD 3 METHOD 4 METHOD 5 METHOD 6
   CMETHOD 7')
```

```
      WRITE(7,320) (UN,IC=1,8),(UN,JC=1,8),(UN,KC=1,8),(UN,LC=1,8),(UN,M
     CC=1,8),(UN,NC=1,8),(UN,NC1=1,8)
  320 FORMAT('+',9X,8A1,1X,8A1,1X,8A1,1X,8A1,1X,8A1,1X,8A1,1X,8A1)
      WRITE(7,330)
  330 FORMAT(20X)
      DO 350 M=1,7
         WRITE(7,340) M,ALEQMN(M,1),ALEQMN(M,2),ALEQMN(M,3),ALEQMN(M,4),
     CALEQMN(M,5),ALEQMN(M,6),ALEQMN(M,7)
  340    FORMAT(' METHOD',I2,7F9.5)
  350 CONTINUE
      WRITE(7,360)
  360 FORMAT(20X)
      WRITE(7,370)
  370 FORMAT(20X)
*
*
      WRITE(7,380)
  380 FORMAT(16X,'TABLE OF P-VALUES FOR REJECTING XBAR > YBAR')
      WRITE(7,390) (UN,IC=1,43)
  390 FORMAT('+',15X,43A1)
      WRITE(7,400)
  400 FORMAT(20X)
      WRITE(7,410)
  410 FORMAT(9X,' METHOD 1 METHOD 2 METHOD 3 METHOD 4 METHOD 5 METHOD 6
     CMETHOD 7')
      WRITE(7,420) (UN,IC=1,8),(UN,JC=1,8),(UN,KC=1,8),(UN,LC=1,8),(UN,M
     CC=1,8),(UN,NC=1,8),(UN,NC1=1,8)
  420 FORMAT('+',9X,8A1,1X,8A1,1X,8A1,1X,8A1,1X,8A1,1X,8A1,1X,8A1)
      WRITE(7,430)
  430 FORMAT(20X)
      DO 450 M=1,7
         WRITE(7,440) M,ALGTMN(M,1),ALGTMN(M,2),ALGTMN(M,3),ALGTMN(M,4),
     CALGTMN(M,5),ALGTMN(M,6),ALGTMN(M,7)
  440    FORMAT(' METHOD',I2,7F9.5)
  450 CONTINUE
      WRITE(7,460)
  460 FORMAT(20X)
      WRITE(7,470)
  470 FORMAT(20X)
*
*
      WRITE(7,480)
  480 FORMAT(16X,'TABLE OF P-VALUES FOR REJECTING XBAR < YBAR')
      WRITE(7,490) (UN,IC=1,43)
  490 FORMAT('+',15X,43A1)
      WRITE(7,500)
  500 FORMAT(20X)
      WRITE(7,510)
  510 FORMAT(9X,' METHOD 1 METHOD 2 METHOD 3 METHOD 4 METHOD 5 METHOD 6
     CMETHOD 7')
      WRITE(7,520) (UN,IC=1,8),(UN,JC=1,8),(UN,KC=1,8),(UN,LC=1,8),(UN,M
     CC=1,8),(UN,NC=1,8),(UN,NC1=1,8)
  520 FORMAT('+',9X,8A1,1X,8A1,1X,8A1,1X,8A1,1X,8A1,1X,8A1,1X,8A1)
      WRITE(7,530)
  530 FORMAT(20X)
      DO 550 M=1,7
         WRITE(7,540) M,ALLTMN(M,1),ALLTMN(M,2),ALLTMN(M,3),ALLTMN(M,4),
     CALLTMN(M,5),ALLTMN(M,6),ALLTMN(M,7)
  540    FORMAT(' METHOD',I2,7F9.5)
  550 CONTINUE
      WRITE(7,560)
  560 FORMAT(20X)
      WRITE(7,570)
  570 FORMAT(20X)
      STOP
      END
*
*
*
*
**********************************************************************
      SUBROUTINE ANOVA(SYIJSQ,TOTSUM,TOTNUM,AMGPOP,DFA,DFE,F663,PRBF,UN,
```

```
     CDASH)
*
*This subroutine uses the intial ANOVA computations, computes the final
*ANOVA values, and prints an ANOVA table.
*
      REAL MSA, MSE
      DIMENSION F663(11), PRBF(11)
      SST=SYIJSQ-(TOTSUM**2)/TOTNUM
      SSA=AMGPOP-(TOTSUM**2)/TOTNUM
      SSE=SST-SSA
      MSA=SSA/DFA
      MSE=SSE/DFE
      FSTAR=MSA/MSE
      DO 575 KR=2,11
*
*Critical level computation
*
         IF(FSTAR.LT.F663(KR)) THEN
            FRATIO=(FSTAR-F663(KR-1))/(F663(KR)-F663(KR-1))
            PRBS=PRBF(KR-1)+FRATIO*(PRBF(KR)-PRBF(KR-1))
            SIGLVL=1.0-PRBS
            GOTO 578
          ELSE
         END IF
  575 CONTINUE
  578 WRITE(7,580)(DASH,IC=1,5),(DASH,JC=1,5)
  580 FORMAT(26X,5A1,'ANOVA TABLE',5A1)
      WRITE(7,583)
  583 FORMAT('0',20X)
      WRITE(7,585)
  585 FORMAT(6X,'SOURCE',9X,'SS',8X,'DF',9X,'MS',10X,'FSTAT',8X,'SIGLVL'
     C)
      WRITE(7,590) (UN,IC=1,6),(UN,JC=1,9),(UN,KC=1,2),(UN,LC=1,9),(UN,M
     CC=1,9),(UN,NC=1,8)
  590 FORMAT('+',5X,6A1,5X,9A1,5X,2A1,5X,9A1,5X,9A1,5X,8A1)
      IDFA=INT(DFA)
      IDFE=INT(DFE)
      IDFT=IDFA+IDFE
      WRITE(7,592) SSA,IDFA,MSA,FSTAR,SIGLVL
  592 FORMAT(6X,'METHOD',5X,F9.3,5X,I2,5X,F9.3,5X,F9.5,5X,F8.5)
      WRITE(7,595) SSE,IDFE,MSE
  595 FORMAT(6X,'ERROR',6X,F9.3,5X,I2,5X,F9.3)
      WRITE(7,600) (UN,IC=1,68)
  600 FORMAT('+',5X,68A1)
      WRITE(7,610) SST,IDFT
  610 FORMAT(6X,'TOTAL',6X,F9.3,5X,I2)
      WRITE(7,620)
  620 FORMAT('0',20X)
      RETURN
      END
*
**********************************************************************
      SUBROUTINE EQUVAR(FM1M2,PRBF,FD1D2,TM1M2,T,PRBT,M1,M2,XM1,XM2,SVAR
     CM1,SVARM2,NM1,NM2,ALPHEQ,ALPHGT,ALPHLT,T11,T12,T13,T14,TWEL)
*
*This subroutine performs an F-test checking for equal variances.  If
*the critical value is less than .05 (i.e., unequal variances), then
*the Behrens-Fisher-Welch subroutine is called.  If not (critical level
*greater to or equal .05), then t-test subroutines are called.
*
      DIMENSION PRBF(11), PRBT(13), T(13), FD1D2(11)
      FMM12=ABS(FM1M2)
      RATIO1=(.025-PRBF(2))/(PRBF(3)-PRBF(2))
      FLO=FD1D2(2)+RATIO1*(FD1D2(3)-FD1D2(2))
      RATIO2=(.975-PRBF(9))/(PRBF(10)-PRBF(9))
      FHI=FD1D2(9)+RATIO2*(FD1D2(10)-FD1D2(9))
      IF(FMM12.LT.FLO.OR.FMM12.GT.FHI) THEN
            CALL WELCH(XM1,XM2,SVARM1,SVARM2,NM1,NM2,M1,M2,T11,T12,T13,T
     C14,TWEL,PRBT)
         ELSE
            CALL EQMEAN(TM1M2,T,PRBT,ALPHEQ)
            CALL GTMEAN(TM1M2,T,PRBT,ALPHGT)
```

```
          CALL LTMEAN(TM1M2,T,PRBT,ALPHLT)
      END IF
      RETURN
      END
*
******************************************************************************
      SUBROUTINE WELCH(XM1,XM2,SVARM1,SVARM2,NM1,NM2,M1,M2,T11,T12,T13,T
     C14,TWEL,PRBT)
*
*This subroutine computes the Behrens-Fisher-Welch statistics.  The
*critical levels of this test are computed using the same subroutines
*as the t-test.
*
      DIMENSION USTAT(7,7), D(7,7)
      UNUM=XM1-XM2
      UDEN=SVARM1/REAL(NM1)+SVARM2/REAL(NM2)
      USTAT(M1,M2)=UNUM/(UDEN**.5)
      DFNUM=UDEN**2
      DFDENL=(SVARM1**2)/REAL((NM1-1)*(NM1**2))
      DFDENR=(SVARM2**2)/REAL((NM2-1)*(NM2**2))
      D(M1,M2)=DFNUM/(DFDENL+DFDENR)
      IF(D(M1,M2).LT.12) THEN
          CALL WELCHT(T11,T12,TWEL,D(M1,M2))
        ELSE IF(D(M1,M2).LT.13) THEN
          CALL WELCHT(T12,T13,TWEL,D(M1,M2))
        ELSE
          CALL WELCHT(T13,T14,TWEL,D(M1,M2))
      END IF
      CALL EQMEAN(USTAT(M1,M2),TWEL,PRBT,WALPEQ)
      CALL GTMEAN(USTAT(M1,M2),TWEL,PRBT,WALPGT)
      CALL LTMEAN(USTAT(M1,M2),TWEL,PRBT,WALPLT)
      WRITE(7,630) M1,M2,USTAT(M1,M2)
*
*Welch critical level output
*
  630 FORMAT(5X,'THE WELCH STATISTIC FOR METHOD',I2,' AND METHOD',I2,' I
     CS:   ',F7.3)
      WRITE(7,640) D(M1,M2)
  640 FORMAT(5X,'WITH ',F7.3,' DEGREES OF FREEDOM.')
      WRITE(7,642) WALPEQ
  642 FORMAT(5X,'THE P-VALUE FOR REJECTING XBAR = YBAR IS:   ',F7.3)
      WRITE(7,644) WALPGT
  644 FORMAT(5X,'THE P-VALUE FOR REJECTING XBAR > YBAR IS:   ',F7.3)
      WRITE(7,646) WALPLT
  646 FORMAT(5X,'THE P-VALUE FOR REJECTING XBAR < YBAR IS:   ',F7.3)
      WRITE(7,650)
  650 FORMAT(20X)
      WRITE(7,660)
  660 FORMAT(20X)
      RETURN
      END
*
******************************************************************************
      SUBROUTINE EQMEAN(TM1M2,T,PRBT,ALPHEQ)
*
*This subroutine computes the critical level of the null hypotesis that
*MU1 = MU2.
*
      DIMENSION PRBT(13), T(13)
      TM12=ABS(TM1M2)
      IF(TM12.LT.T(1)) THEN
          ALPHEQ=.9
        ELSE IF(TM12.GT.T(13)) THEN
          ALPHEQ=.001
        ELSE
          DO 670 K=2,13
             IF(TM12.LT.T(K)) THEN
                  RATIO=(TM12-T(K-1))/(T(K)-T(K-1))
                  PRBT1=PRBT(K-1)+RATIO*(PRBT(K)-PRBT(K-1))
                  ALPHEQ=(1.0-PRBT1)*2.0
                  GOTO 675
                ELSE
```

```
               END IF
  670        CONTINUE
  675 END IF
      RETURN
      END
*
******************************************************************************
      SUBROUTINE GTMEAN(TM1M2,T,PRBT,ALPHGT)
*
*This subroutine computes the critical level of the null hypotesis that
*MU1 >= MU2.
*
      DIMENSION PRBT(13), T(13)
      TM12=ABS(TM1M2)
      IF(TM12.LT.T(1)) THEN
            ALPHGT=.55
            IF(TM1M2.LT.0.0) ALPHGT=1.0-ALPHGT
         ELSE IF(TM12.GT.T(13)) THEN
            ALPHGT=.9995
            IF(TM1M2.LT.0.0) ALPHGT=1.0-ALPHGT
         ELSE
            DO 680 K=2,13
               IF(TM12.LT.T(K)) THEN
                    RATIO=(TM12-T(K-1))/(T(K)-T(K-1))
                    PRBT1=PRBT(K-1)+RATIO*(PRBT(K)-PRBT(K-1))
                    ALPHGT=PRBT1
                    IF(TM1M2.LT.0.0) ALPHGT=1.0-ALPHGT
                    GOTO 685
                  ELSE
               END IF
  680        CONTINUE
  685 END IF
      RETURN
      END
*
******************************************************************************
      SUBROUTINE LTMEAN(TM1M2,T,PRBT,ALPHLT)
*
*This subroutine computes the critical level of the null hypotesis that
*MU1 <= MU2.
*
      DIMENSION PRBT(13), T(13)
      TM12=ABS(TM1M2)
      IF(TM12.LT.T(1)) THEN
            ALPHLT=.45
            IF(TM1M2.LT.0.0) ALPHLT=1.0-ALPHLT
         ELSE IF(TM12.GT.T(13)) THEN
            ALPHLT=.0005
            IF(TM1M2.LT.0.0) ALPHLT=1.0-ALPHLT
         ELSE
            DO 690 K=2,13
               IF(TM12.LT.T(K)) THEN
                    RATIO=(TM12-T(K-1))/(T(K)-T(K-1))
                    PRBT1=PRBT(K-1)+RATIO*(PRBT(K)-PRBT(K-1))
                    ALPHLT=1.0-PRBT1
                    IF(TM1M2.LT.0.0) ALPHLT=1.0-ALPHLT
                    GOTO 695
                  ELSE
               END IF
  690        CONTINUE
  695 END IF
      RETURN
      END
*
******************************************************************************
      SUBROUTINE FCHECK(XX,YY)
*
*Once the degrees of freedom for an F-test are known, this subroutine
*puts the associated F values in a dummy variable, YY, for use in the
*program elsewhere.
*
      DIMENSION XX(11),YY(11)
```

```
      DO 700 I=1,11
         YY(I)=XX(I)
  700 CONTINUE
      RETURN
      END
*
*************************************************************************
      SUBROUTINE TCHECK(XX,YY)
*
*Once the degree of freedom for a t-test is known, this subroutine
*puts the associated t values in a dummy variable, YY, for use in the
*program elsewhere.
*
      DIMENSION XX(13),YY(13)
      DO 710 I=1,13
         YY(I)=XX(I)
  710 CONTINUE
      RETURN
      END
*
***************************************************************************
      SUBROUTINE WELCHT(TA,TB,TWEL,DM12)
*
*This subroutine computes the associated t values for the degrees of
*freedom of the Welch test statistic.
*
      DIMENSION TA(13), TB(13), TWEL(13)
      JDFINT=INT(DM12)
      FRCTN=DM12-REAL(JDFINT)
      DO 720 KT=1,13
         TWEL(KT)=TA(KT)+FRCTN*(TB(KT)-TA(KT))
  720 CONTINUE
      RETURN
      END
```

APPENDIX H

STATISTICAL RESULTS

0.0000 - Placeholder (either a method was not compared against itself or a Welch test was performed for that case)
XBAR - mu of the row method
YBAR - mu of the column method

METHOD	TYPE OF TRAINING
1	LECTURE
2	VIDEO
3	READING
4	CONTROL
5	AUDIO 1.00
6	AUDIO 1.25
7	AUDIO 1.50

1. Chi-square Goodness of Fit Test Results

Input Data	Mean	Std Dev	Test Statistic	Crt Lvl
INITIAL	20.76	6.509	14.0539	0.23525
RETENTION	21.21	4.650	15.6872	0.16720
OLD QUEST	15.92	2.730	16.3958	0.13768
NEW QUEST	5.13	2.640	10.2583	0.50383
GPA	2.82	0.556	14.5692	0.21378

2. All Test Scores
   A. Data Analysis
      (1) Initial Test

	------------SAMPLE------------			----RANGE----	
	MEAN	VARIANCE	STD DEV	HIGH	LOW
METHOD 1	18.450	50.025	7.073	34.0	11.5
METHOD 2	21.150	39.503	6.285	32.0	11.5
METHOD 3	21.563	24.888	4.989	26.5	14.0
METHOD 4	13.667	25.924	5.092	19.5	4.0
METHOD 5	24.350	73.947	8.599	37.5	10.0
METHOD 6	24.500	80.889	8.994	38.0	10.0
METHOD 7	23.200	20.511	4.529	31.5	19.0

(2) Retention Test

	------------SAMPLE------------			----RANGE----	
	MEAN	VARIANCE	STD DEV	HIGH	LOW
METHOD 1	20.250	25.458	5.046	28.0	13.0
METHOD 2	21.300	15.344	3.917	26.5	14.0
METHOD 3	22.125	11.625	3.410	26.0	16.0
METHOD 4	17.208	14.839	3.852	24.0	10.0
METHOD 5	24.300	18.011	4.244	32.0	17.0
METHOD 6	21.900	38.600	6.213	32.0	11.0
METHOD 7	21.250	35.014	5.917	28.5	13.0

(3) Old Questions

	SAMPLE			RANGE	
	MEAN	VARIANCE	STD DEV	HIGH	LOW
METHOD 1	15.100	10.267	3.204	19.5	10.0
METHOD 2	16.650	3.558	1.886	19.0	14.0
METHOD 3	16.500	2.286	1.512	19.0	14.0
METHOD 4	13.958	7.930	2.816	18.0	8.0
METHOD 5	17.000	6.222	2.494	21.0	13.0
METHOD 6	16.550	13.803	3.715	22.0	11.0
METHOD 7	16.200	11.956	3.458	20.5	11.0

(4) New Questions

	SAMPLE			RANGE	
	MEAN	VARIANCE	STD DEV	HIGH	LOW
METHOD 1	5.150	6.947	2.636	9.5	1.0
METHOD 2	4.650	8.614	2.935	9.5	0.0
METHOD 3	5.625	5.482	2.341	9.0	2.0
METHOD 4	3.250	2.295	1.515	6.0	2.0
METHOD 5	7.300	7.344	2.710	11.5	3.5
METHOD 6	5.350	11.392	3.375	12.0	0.0
METHOD 7	5.050	8.803	2.967	9.0	0.0

B. Analysis of the Initial Test Scores
(1) One-way ANOVA

SOURCE	SS	DF	MS	FSTAT	CRTLVL
METHOD	992.105	6	165.351	3.66378	0.00598
ERROR	2843.270	63	45.131		
TOTAL	3835.375	69			

(2) Two Sample t-tests

Table of Critical Values for Rejecting XBAR = YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.37982	0.30983	0.08221	0.10657	0.10754	0.08894
METHOD 2	0.37982	0.00000	0.88374	0.00764	0.35712	0.34977	0.41348
METHOD 3	0.30983	0.88374	0.00000	0.00528	0.43269	0.42517	0.47835
METHOD 4	0.08221	0.00764	0.00528	0.00000	0.00330	0.00382	0.00100
METHOD 5	0.10657	0.35712	0.43269	0.00330	0.00000	0.90000	0.71350
METHOD 6	0.10754	0.34977	0.42517	0.00382	0.90000	0.00000	0.68823
METHOD 7	0.08894	0.41348	0.47835	0.00100	0.71350	0.00000	0.00000

Table of Critical values for Rejecting XBAR > YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.18991	0.15491	0.95890	0.05329	0.05377	0.04447
METHOD 2	0.81009	0.00000	0.44187	0.99618	0.17856	0.17488	0.20674
METHOD 3	0.84509	0.55813	0.00000	0.99736	0.21634	0.21259	0.23917
METHOD 4	0.04110	0.00382	0.00264	0.00000	0.00165	0.00191	0.00050
METHOD 5	0.94671	0.82144	0.78366	0.99835	0.00000	0.45000	0.64325
METHOD 6	0.94623	0.82512	0.78741	0.99809	0.55000	0.00000	0.65589
METHOD 7	0.95553	0.79326	0.76083	0.99950	0.35675	0.00000	0.00000

Table of Critical Values for Rejecting XBAR < YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.81009	0.84509	0.04110	0.94671	0.94623	0.95553
METHOD 2	0.18991	0.00000	0.55813	0.00382	0.82144	0.82512	0.79326
METHOD 3	0.15491	0.44187	0.00000	0.00264	0.78366	0.78741	0.76083
METHOD 4	0.95890	0.99618	0.99736	0.00000	0.99835	0.99809	0.99950
METHOD 5	0.05329	0.17856	0.21634	0.00165	0.00000	0.55000	0.35675
METHOD 6	0.05377	0.17488	0.21259	0.00191	0.45000	0.00000	0.34411
METHOD 7	0.04447	0.20674	0.23917	0.00050	0.64325	0.00000	0.00000

(3) Welch Test Result

THE WELCH STATISTIC FOR METHOD 7 AND METHOD 6 IS: -0.408
WITH 13.289 DEGREES OF FREEDOM.
THE CRITICAL VALUE FOR REJECTING XBAR = YBAR IS: 0.690
THE CRITICAL VALUE FOR REJECTING XBAR > YBAR IS: 0.345
THE CRITICAL VALUE FOR REJECTING XBAR < YBAR IS: 0.655

C. Analysis of the Retention Test Scores
(1) One-way ANOVA

SOURCE	SS	DF	MS	FSTAT	CRTLVL
METHOD	306.621	6	51.104	2.24129	0.04994
ERROR	1436.461	63	22.801		
TOTAL	1743.082	69			

(2) Two Sample t-tests

Table of Critical Values for Rejecting XBAR = YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.60739	0.38635	0.12530	0.06969	0.52283	0.68938
METHOD 2	0.60739	0.00000	0.64756	0.02286	0.11551	0.80128	0.90000
METHOD 3	0.38635	0.64756	0.00000	0.00980	0.26095	0.90000	0.71624
METHOD 4	0.12530	0.02286	0.00980	0.00000	0.00100	0.04486	0.07124
METHOD 5	0.06969	0.11551	0.26095	0.00100	0.00000	0.32919	0.20211
METHOD 6	0.52283	0.80128	0.90000	0.04486	0.32919	0.00000	0.81572
METHOD 7	0.68938	0.90000	0.71624	0.07124	0.20211	0.81572	0.00000

Table of Critical Values for Rejecting XBAR > YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.30369	0.19317	0.93735	0.03484	0.26142	0.34469
METHOD 2	0.69631	0.00000	0.32378	0.98857	0.05775	0.40064	0.55000
METHOD 3	0.80683	0.67622	0.00000	0.99510	0.13047	0.55000	0.64188
METHOD 4	0.06265	0.01143	0.00490	0.00000	0.00050	0.02243	0.03562
METHOD 5	0.96516	0.94225	0.86953	0.99950	0.00000	0.83540	0.89895
METHOD 6	0.73858	0.59936	0.45000	0.97757	0.16460	0.00000	0.59214
METHOD 7	0.65531	0.45000	0.35812	0.96438	0.10105	0.40786	0.00000

Table of Critical Values for Rejecting XBAR < YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.69631	0.80683	0.06265	0.96516	0.73858	0.65531
METHOD 2	0.30369	0.00000	0.67622	0.01143	0.94225	0.59936	0.45000
METHOD 3	0.19317	0.32378	0.00000	0.00490	0.86953	0.45000	0.35812
METHOD 4	0.93735	0.98857	0.99510	0.00000	0.99950	0.97757	0.96438
METHOD 5	0.03484	0.05775	0.13047	0.00050	0.00000	0.16460	0.10105
METHOD 6	0.26142	0.40064	0.55000	0.02243	0.83540	0.00000	0.40786
METHOD 7	0.34469	0.55000	0.64188	0.03562	0.89895	0.59214	0.00000

(3) Welch Tests
-there were no Welch Tests performed

D. Analysis of the Old Questions
(1) One-way ANOVA

SOURCE	SS	DF	MS	FSTAT	CRTLVL
METHOD	77.340	6	12.890	1.57535	0.18372
ERROR	515.484	63	8.182		
TOTAL	592.824	69			

(2) Two Sample t-tests

Table of Critical Values for Rejecting XBAR = YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.20452	0.00000	0.38515	0.15956	0.36447	0.47099
METHOD 2	0.20452	0.00000	0.85960	0.01752	0.72886	0.00000	0.72327
METHOD 3	0.00000	0.85960	0.00000	0.03648	0.62912	0.00000	0.00000
METHOD 4	0.38515	0.01752	0.03648	0.00000	0.01485	0.07981	0.10595
METHOD 5	0.15956	0.72886	0.62912	0.01485	0.00000	0.75605	0.55990
METHOD 6	0.36447	0.90000	0.00000	0.07981	0.75605	0.00000	0.83225
METHOD 7	0.47099	0.72327	0.00000	0.10595	0.55990	0.83225	0.00000

Table of Critical Values for Rejecting XBAR > YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.10226	0.00000	0.80743	0.07978	0.18224	0.23549
METHOD 2	0.89774	0.00000	0.57020	0.99124	0.36443	0.00000	0.63837
METHOD 3	0.00000	0.42980	0.00000	0.98176	0.31456	0.00000	0.00000
METHOD 4	0.19257	0.00876	0.01824	0.00000	0.00742	0.03991	0.05297
METHOD 5	0.92022	0.63557	0.68544	0.99258	0.00000	0.62197	0.72005
METHOD 6	0.81776	0.45000	0.00000	0.96009	0.37803	0.00000	0.58387
METHOD 7	0.76451	0.36163	0.00000	0.94703	0.27995	0.41613	0.00000

Table of Critical Values for Rejecting XBAR < YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.89774	0.00000	0.19257	0.92022	0.81776	0.76451
METHOD 2	0.10226	0.00000	0.42980	0.00876	0.63557	0.00000	0.36163
METHOD 3	0.00000	0.57020	0.00000	0.01824	0.68544	0.00000	0.00000
METHOD 4	0.80743	0.99124	0.98176	0.00000	0.99258	0.96009	0.94703
METHOD 5	0.07978	0.36443	0.31456	0.00742	0.00000	0.37803	0.27995
METHOD 6	0.18224	0.55000	0.00000	0.03991	0.62197	0.00000	0.41613
METHOD 7	0.23549	0.63837	0.00000	0.05297	0.72005	0.58387	0.00000

(3) Welch Tests

```
THE WELCH STATISTIC FOR METHOD 1 AND METHOD 3 IS:    -1.222
WITH  13.375 DEGREES OF FREEDOM.
THE CRITICAL VALUE FOR REJECTING XBAR = YBAR IS:     0.247
THE CRITICAL VALUE FOR REJECTING XBAR > YBAR IS:     0.123
THE CRITICAL VALUE FOR REJECTING XBAR < YBAR IS:     0.877

THE WELCH STATISTIC FOR METHOD 2 AND METHOD 6 IS:     0.076
WITH  13.351 DEGREES OF FREEDOM.
THE CRITICAL VALUE FOR REJECTING XBAR = YBAR IS:     0.900
THE CRITICAL VALUE FOR REJECTING XBAR > YBAR IS:     0.550
THE CRITICAL VALUE FOR REJECTING XBAR < YBAR IS:     0.450

THE WELCH STATISTIC FOR METHOD 3 AND METHOD 1 IS:     1.222
WITH  13.375 DEGREES OF FREEDOM.
THE CRITICAL VALUE FOR REJECTING XBAR = YBAR IS:     0.247
THE CRITICAL VALUE FOR REJECTING XBAR > YBAR IS:     0.877
THE CRITICAL VALUE FOR REJECTING XBAR < YBAR IS:     0.123

THE WELCH STATISTIC FOR METHOD 3 AND METHOD 6 IS:    -0.039
WITH  12.427 DEGREES OF FREEDOM.
THE CRITICAL VALUE FOR REJECTING XBAR = YBAR IS:     0.900
THE CRITICAL VALUE FOR REJECTING XBAR > YBAR IS:     0.450
THE CRITICAL VALUE FOR REJECTING XBAR < YBAR IS:     0.550

THE WELCH STATISTIC FOR METHOD 3 AND METHOD 7 IS:     0.246
WITH  12.871 DEGREES OF FREEDOM.
THE CRITICAL VALUE FOR REJECTING XBAR = YBAR IS:     0.810
THE CRITICAL VALUE FOR REJECTING XBAR > YBAR IS:     0.595
THE CRITICAL VALUE FOR REJECTING XBAR < YBAR IS:     0.405

THE WELCH STATISTIC FOR METHOD 6 AND METHOD 3 IS:     0.039
WITH  12.427 DEGREES OF FREEDOM.
THE CRITICAL VALUE FOR REJECTING XBAR = YBAR IS:     0.900
THE CRITICAL VALUE FOR REJECTING XBAR > YBAR IS:     0.550
THE CRITICAL VALUE FOR REJECTING XBAR < YBAR IS:     0.450

THE WELCH STATISTIC FOR METHOD 7 AND METHOD 3 IS:    -0.246
WITH  12.871 DEGREES OF FREEDOM.
THE CRITICAL VALUE FOR REJECTING XBAR = YBAR IS:     0.810
THE CRITICAL VALUE FOR REJECTING XBAR > YBAR IS:     0.405
THE CRITICAL VALUE FOR REJECTING XBAR < YBAR IS:     0.595
```

E. Analysis of the New Questions

(1) One-way ANOVA

SOURCE	SS	DF	MS	FSTAT	CRTLVL
METHOD	94.317	6	15.720	2.19330	0.05614
ERROR	451.526	63	7.167		
TOTAL	545.843	69			

(2) Two Sample t-tests

Table of Critical Values for Rejecting XBAR = YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.69361	0.69543	0.04864	0.08769	0.88639	0.90000
METHOD 2	0.69361	0.00000	0.45905	0.16780	0.05028	0.62543	0.76735
METHOD 3	0.69543	0.45905	0.00000	0.01441	0.19089	0.84972	0.66275
METHOD 4	0.04864	0.16780	0.01441	0.00000	0.00100	0.00000	0.00000
METHOD 5	0.08769	0.05028	0.19089	0.00100	0.00000	0.17443	0.09117
METHOD 6	0.88639	0.62543	0.84972	0.00000	0.17443	0.00000	0.83761
METHOD 7	0.90000	0.76735	0.66275	0.08258	0.09117	0.83761	0.00000

Table of Critical Values for Rejecting XBAR > YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.65320	0.34771	0.97568	0.04385	0.44320	0.55000
METHOD 2	0.34680	0.00000	0.22952	0.91610	0.02514	0.31272	0.38368
METHOD 3	0.65229	0.77048	0.00000	0.99279	0.09545	0.57514	0.66862
METHOD 4	0.02432	0.08390	0.00721	0.00000	0.00050	0.00000	0.00000
METHOD 5	0.95615	0.97486	0.90455	0.99950	0.00000	0.91278	0.95442
METHOD 6	0.55680	0.68728	0.42486	0.00000	0.08722	0.00000	0.58120
METHOD 7	0.45000	0.61632	0.33138	0.95871	0.04558	0.41880	0.00000

Table of Critical Values for Rejecting XBAR < YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.34680	0.65229	0.02432	0.95615	0.55680	0.45000
METHOD 2	0.65320	0.00000	0.77048	0.08390	0.97486	0.68728	0.61632
METHOD 3	0.34771	0.22952	0.00000	0.00721	0.90455	0.42486	0.33138
METHOD 4	0.97568	0.91610	0.99279	0.00000	0.99950	0.00000	0.00000
METHOD 5	0.04385	0.02514	0.09545	0.00050	0.00000	0.08722	0.04558
METHOD 6	0.44320	0.31272	0.57514	0.00000	0.91278	0.00000	0.41880
METHOD 7	0.55000	0.38368	0.66862	0.04129	0.95442	0.58120	0.00000

(3) Welch Tests

```
THE WELCH STATISTIC FOR METHOD 4 AND METHOD 6 IS:    -1.821
WITH  11.999 DEGREES OF FREEDOM.
THE CRITICAL VALUE FOR REJECTING XBAR = YBAR IS:     0.097
THE CRITICAL VALUE FOR REJECTING XBAR > YBAR IS:     0.049
THE CRITICAL VALUE FOR REJECTING XBAR < YBAR IS:     0.951

THE WELCH STATISTIC FOR METHOD 4 AND METHOD 7 IS:    -1.739
WITH  12.840 DEGREES OF FREEDOM.
THE CRITICAL VALUE FOR REJECTING XBAR = YBAR IS:     0.114
THE CRITICAL VALUE FOR REJECTING XBAR > YBAR IS:     0.057
THE CRITICAL VALUE FOR REJECTING XBAR < YBAR IS:     0.943

THE WELCH STATISTIC FOR METHOD 6 AND METHOD 4 IS:     1.821
WITH  11.999 DEGREES OF FREEDOM.
THE CRITICAL VALUE FOR REJECTING XBAR = YBAR IS:     0.097
THE CRITICAL VALUE FOR REJECTING XBAR > YBAR IS:     0.951
THE CRITICAL VALUE FOR REJECTING XBAR < YBAR IS:     0.049
```

3. Equal Group Size Test Scores

A. Data analysis

(1) Initial Test

	SAMPLE MEAN	SAMPLE VARIANCE	SAMPLE STD DEV	RANGE HIGH	RANGE LOW
METHOD 1	16.938	25.460	5.046	26.5	11.5
METHOD 2	20.500	40.500	6.364	32.0	11.5
METHOD 3	21.563	24.888	4.989	26.5	14.0
METHOD 4	12.438	29.674	5.447	19.0	4.0
METHOD 5	26.250	61.429	7.838	37.5	18.0
METHOD 6	27.500	50.786	7.126	38.0	14.5
METHOD 7	23.500	23.286	4.826	31.5	19.0

(2) Retention Test

	SAMPLE MEAN	SAMPLE VARIANCE	SAMPLE STD DEV	RANGE HIGH	RANGE LOW
METHOD 1	19.250	24.857	4.986	28.0	13.0
METHOD 2	21.438	16.603	4.075	26.5	14.0
METHOD 3	22.125	11.625	3.410	26.0	16.0
METHOD 4	16.750	14.286	3.780	21.0	10.0
METHOD 5	24.313	22.710	4.765	32.0	17.0
METHOD 6	23.500	29.214	5.405	32.0	14.5
METHOD 7	21.375	27.768	5.270	28.5	13.0

(3) Old Questions

	SAMPLE MEAN	SAMPLE VARIANCE	SAMPLE STD DEV	RANGE HIGH	RANGE LOW
METHOD 1	14.125	7.696	2.774	18.5	10.0
METHOD 2	16.625	3.125	1.768	19.0	14.0
METHOD 3	16.500	2.286	1.512	19.0	14.0
METHOD 4	13.500	8.286	2.878	16.0	8.0
METHOD 5	17.125	7.839	2.800	21.0	13.0
METHOD 6	17.563	11.246	3.353	22.0	11.0
METHOD 7	16.063	11.246	3.353	19.5	11.0

(4) New Questions

	SAMPLE MEAN	SAMPLE VARIANCE	SAMPLE STD DEV	RANGE HIGH	RANGE LOW
METHOD 1	5.125	7.482	2.735	9.5	1.0
METHOD 2	4.813	10.638	3.262	9.5	0.0
METHOD 3	5.625	5.482	2.341	9.0	2.0
METHOD 4	3.250	2.143	1.464	5.5	2.0
METHOD 5	7.188	9.210	3.035	11.5	3.5
METHOD 6	5.938	10.103	3.178	12.0	3.0
METHOD 7	5.313	6.353	2.520	9.0	2.0

B. Analysis of the Initial Test

(1) One-way ANOVA

SOURCE	SS	DF	MS	FSTAT	CRTLVL
METHOD	1328.344	6	221.391	6.05312	0.00100
ERROR	1792.156	49	36.575		
TOTAL	3120.500	55			

(2) Individual Degrees of Freedom ANOVA

SOURCE	SS	DF	MS	FSTAT	CRTLVL
4V12356	723.360	1	723.360	19.77765	0.00100
123V567	444.083	1	444.083	12.14184	0.00126
12 V 3	43.130	1	43.130	1.17924	0.30021
56 V 7	60.750	1	60.750	1.66099	0.21865
1 V 2	50.766	1	50.766	1.38800	0.24708
5 V 6	6.250	1	6.250	0.17088	0.70246
ERROR	1792.156	49	36.575		
TOTAL	3120.500	55			

(3) Two Sample t-tests

Table of Critical Values for Rejecting XBAR = YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.23820	0.09273	0.11866	0.01436	0.00655	0.01354
METHOD 2	0.23820	0.00000	0.71606	0.01694	0.14111	0.05463	0.30836
METHOD 3	0.09273	0.71606	0.00000	0.00596	0.18108	0.07825	0.44520
METHOD 4	0.11866	0.01694	0.00596	0.00000	0.00106	0.00100	0.00100
METHOD 5	0.01436	0.14111	0.18108	0.00106	0.00000	0.74454	0.41400
METHOD 6	0.00655	0.05463	0.07825	0.00100	0.74454	0.00000	0.20979
METHOD 7	0.01854	0.30836	0.44520	0.00100	0.41400	0.20979	0.00000

Table of Critical Values for Rejecting XBAR > YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.11910	0.04637	0.94067	0.00718	0.00328	0.00927
METHOD 2	0.88090	0.00000	0.35803	0.99153	0.07056	0.02731	0.15418
METHOD 3	0.95363	0.64197	0.00000	0.99702	0.09054	0.03912	0.22260
METHOD 4	0.05933	0.00847	0.00298	0.00000	0.00053	0.00050	0.00050
METHOD 5	0.99282	0.92944	0.90946	0.99947	0.00000	0.37227	0.79300
METHOD 6	0.99672	0.97269	0.96088	0.99950	0.62773	0.00000	0.89511
METHOD 7	0.99073	0.84582	0.77740	0.99950	0.20700	0.10489	0.00000

Table of Critical Values for Rejecting XBAR < YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.38090	0.95363	0.05933	0.99282	0.99672	0.99073
METHOD 2	0.11910	0.00000	0.64197	0.00847	0.92944	0.97269	0.84582
METHOD 3	0.04637	0.35803	0.00000	0.00298	0.90946	0.96088	0.77740
METHOD 4	0.94067	0.99153	0.99702	0.00000	0.99947	0.99950	0.99950
METHOD 5	0.00718	0.07056	0.09054	0.00053	0.00000	0.62773	0.20700
METHOD 6	0.00328	0.02731	0.03912	0.00050	0.37227	0.00000	0.10489
METHOD 7	0.00927	0.15418	0.22260	0.00050	0.79300	0.89511	0.00000

(4) Welch Tests
-no Welch Tests were performed

C. Analysis of the Retention Test

(1) One-way ANOVA

SOURCE	SS	DF	MS	FSTAT	CRTLVL
METHOD	316.062	6	52.677	2.50737	0.04078
ERROR	1029.437	49	21.009		
TOTAL	1345.500	55			

(2) Individual degrees of freedom ANOVA

SOURCE	SS	DF	MS	FSTAT	CRTLVL
4V12356	189.000	1	189.000	8.99618	0.00682
123V567	54.188	1	54.188	2.57926	0.12299
12 V 3	16.922	1	16.922	0.80546	0.40404
56 V 7	34.172	1	34.172	1.62654	0.22224
1 V 2	19.141	1	19.141	0.91107	0.37470
5 V 6	2.641	1	2.641	0.12569	0.73411
ERROR	1029.437	49	21.009		
TOTAL	1345.500	55			

(3) Two Sample t-tests

Table of Critical Values for Rejecting XBAR = YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.35671	0.19863	0.28069	0.05398	0.13593	0.42330
METHOD 2	0.35671	0.00000	0.72030	0.03287	0.21656	0.40459	0.90000
METHOD 3	0.19863	0.72030	0.00000	0.01033	0.31147	0.55489	0.74136
METHOD 4	0.28069	0.03287	0.01033	0.00000	0.00577	0.01263	0.06379
METHOD 5	0.05398	0.21656	0.31147	0.00577	0.00000	0.75570	0.26560
METHOD 6	0.13593	0.40459	0.55489	0.01263	0.75570	0.00000	0.44145
METHOD 7	0.42330	0.90000	0.74136	0.06379	0.26560	0.44145	0.00000

Table of Critical Values for Rejecting XBAR > YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.17836	0.09931	0.85966	0.02699	0.06796	0.21165
METHOD 2	0.82164	0.00000	0.36015	0.98357	0.10828	0.20229	0.55000
METHOD 3	0.90069	0.63985	0.00000	0.99483	0.15574	0.27744	0.62932
METHOD 4	0.14034	0.01643	0.00517	0.00000	0.00289	0.00632	0.03190
METHOD 5	0.97301	0.89172	0.84426	0.99711	0.00000	0.62215	0.86720
METHOD 6	0.93204	0.79771	0.72256	0.99368	0.37785	0.00000	0.77928
METHOD 7	0.78835	0.45000	0.37068	0.96810	0.13280	0.22072	0.00000

Table of Critical Values for Rejecting XBAR < YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.82164	0.90069	0.14034	0.97301	0.93204	0.78835
METHOD 2	0.17836	0.00000	0.63985	0.01643	0.89172	0.79771	0.45000
METHOD 3	0.09931	0.36015	0.00000	0.00517	0.84426	0.72256	0.37068
METHOD 4	0.85966	0.98357	0.99483	0.00000	0.99711	0.99368	0.96810
METHOD 5	0.02699	0.10828	0.15574	0.00289	0.00000	0.37785	0.13280
METHOD 6	0.06796	0.20229	0.27744	0.00632	0.62215	0.00000	0.22072
METHOD 7	0.21165	0.55000	0.62932	0.03190	0.86720	0.77928	0.00000

(4) Welch Tests
-no Welch Tests were preformed

D. Analysis of the Old Questions
(1) One-way ANOVA

SOURCE	SS	DF	MS	FSTAT	CRTLVL
METHOD	112.652	6	18.775	2.54098	0.03929
ERROR	362.062	49	7.389		
TOTAL	474.715	55			

(2) Individual Degrees of Freedom Anova

SOURCE	SS	DF	MS	FSTAT	CRTLVL
4V12356	55.048	1	55.048	7.44991	0.00956
123V567	16.333	1	16.333	2.21048	0.16141
12 V 3	6.750	1	6.750	0.91352	0.37402
56 V 7	8.755	1	8.755	1.18489	0.29864
1 V 2	25.000	1	25.000	3.38339	0.07648
5 V 6	0.766	1	0.766	0.10362	0.74957
ERROR	362.062	49	7.389		
TOTAL	474.715	55			

(3) Two Sample t-tests

Table of Critical Values for Rejecting XBAR = YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.04703	0.04843	0.66654	0.04683	0.04196	0.23110
METHOD 2	0.04703	0.00000	0.88308	0.01958	0.67681	0.49579	0.68184
METHOD 3	0.04843	0.88308	0.00000	0.01976	0.58977	0.00000	0.00000
METHOD 4	0.66654	0.01958	0.01976	0.00000	0.02280	0.02000	0.13478
METHOD 5	0.04683	0.67681	0.58977	0.02280	0.00000	0.78251	0.50269
METHOD 6	0.04196	0.49579	0.42979	0.02000	0.78251	0.00000	0.38828
METHOD 7	0.23110	0.68184	0.74256	0.13478	0.50269	0.38828	0.00000

Table of Critical Values for Rejecting XBAR > YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.02351	0.02422	0.66673	0.02342	0.02098	0.11555
METHOD 2	0.97649	0.00000	0.55846	0.99021	0.33840	0.24790	0.65908
METHOD 3	0.97578	0.44154	0.00000	0.99012	0.29488	0.00000	0.00000
METHOD 4	0.33327	0.00979	0.00988	0.00000	0.01140	0.01000	0.06739
METHOD 5	0.97658	0.66160	0.70512	0.98860	0.00000	0.39126	0.74865
METHOD 6	0.97902	0.75210	0.78510	0.99000	0.60874	0.00000	0.80586
METHOD 7	0.88445	0.34092	0.37128	0.93261	0.25135	0.19414	0.00000

Table of Critical Values for Rejecting XBAR < YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.97649	0.97578	0.33327	0.97658	0.97902	0.88445
METHOD 2	0.02351	0.00000	0.44154	0.00979	0.66160	0.75210	0.34092
METHOD 3	0.02422	0.55846	0.00000	0.00988	0.70512	0.00000	0.00000
METHOD 4	0.66673	0.99021	0.99012	0.00000	0.98860	0.99000	0.93261
METHOD 5	0.02342	0.33840	0.29488	0.01140	0.00000	0.60874	0.25135
METHOD 6	0.02098	0.24790	0.21490	0.01000	0.39126	0.00000	0.19414
METHOD 7	0.11555	0.65908	0.62872	0.06739	0.74865	0.80586	0.00000

(4) Welch Tests

```
THE WELCH STATISTIC FOR METHOD 3 AND METHOD 6 IS:    -0.817
WITH   9.733 DEGREES OF FREEDOM.
THE CRITICAL VALUE FOR REJECTING XBAR = YBAR IS:     0.435
THE CRITICAL VALUE FOR REJECTING XBAR > YBAR IS:     0.218
THE CRITICAL VALUE FOR REJECTING XBAR < YBAR IS:     0.782

THE WELCH STATISTIC FOR METHOD 3 AND METHOD 7 IS:     0.336
WITH   9.733 DEGREES OF FREEDOM.
THE CRITICAL VALUE FOR REJECTING XBAR = YBAR IS:     0.744
THE CRITICAL VALUE FOR REJECTING XBAR > YBAR IS:     0.628
THE CRITICAL VALUE FOR REJECTING XBAR < YBAR IS:     0.372
```

E. Analysis of the New Questions

(1) One-way ANOVA

SOURCE	SS	DF	MS	FSTAT	CRTLVL
METHOD	68.339	6	11.390	1.55083	0.19699
ERROR	359.875	49	7.344		
TOTAL	428.214	55			

(2) Individual Degrees of Freedom ANOVA

SOURCE	SS	DF	MS	FSTAT	CRTLVL
4V12356	40.048	1	40.048	5.45282	0.03212
123V567	11.021	1	11.021	1.50058	0.23536
12 V 3	2.297	1	2.297	0.31274	0.60312
56 V 7	8.333	1	8.333	1.13465	0.31260
1 V 2	0.391	1	0.391	0.05319	0.83588
5 V 6	6.250	1	6.250	0.85099	0.39139
ERROR	359.875	49	7.344		
TOTAL	428.214	55			

(3) Two Sample t-tests

Table of Critical Values for Rejecting XBAR = YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.84028	0.70017	0.11969	0.18090	0.59472	0.89032
METHOD 2	0.84028	0.00000	0.57870	0.23993	0.16352	0.49624	0.73753
METHOD 3	0.70017	0.57870	0.00000	0.03004	0.27193	0.82777	0.80236
METHOD 4	0.11969	0.00000	0.03004	0.00000	0.00750	0.00000	0.06643
METHOD 5	0.18090	0.16352	0.27193	0.00750	0.00000	0.43679	0.19906
METHOD 6	0.59472	0.49624	0.82777	0.04567	0.43679	0.00000	0.67090
METHOD 7	0.89032	0.73753	0.80236	0.06643	0.19906	0.67090	0.00000

Table of Critical Values for Rejecting XBAR > YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.57986	0.35009	0.94015	0.09045	0.29736	0.44516
METHOD 2	0.42014	0.00000	0.28935	0.88003	0.08176	0.24812	0.36876
METHOD 3	0.64991	0.71065	0.00000	0.98498	0.13596	0.41389	0.59882
METHOD 4	0.05985	0.00000	0.01502	0.00000	0.00375	0.00000	0.03321
METHOD 5	0.90955	0.91824	0.86404	0.99625	0.00000	0.78161	0.90047
METHOD 6	0.70264	0.75188	0.58611	0.97717	0.21839	0.00000	0.66455
METHOD 7	0.55484	0.63124	0.40118	0.96679	0.09953	0.33545	0.00000

Table of Critical Values for Rejecting XBAR < YBAR

	METHOD 1	METHOD 2	METHOD 3	METHOD 4	METHOD 5	METHOD 6	METHOD 7
METHOD 1	0.00000	0.42014	0.64991	0.05985	0.90955	0.70264	0.55484
METHOD 2	0.57986	0.00000	0.71065	0.11997	0.91824	0.75188	0.63124
METHOD 3	0.35009	0.28935	0.00000	0.01502	0.86404	0.58611	0.40118
METHOD 4	0.94015	0.00000	0.98498	0.00000	0.99625	0.00000	0.96679
METHOD 5	0.09045	0.08176	0.13596	0.00375	0.00000	0.21839	0.09953
METHOD 6	0.29736	0.24812	0.41389	0.02283	0.78161	0.00000	0.33545
METHOD 7	0.44516	0.36876	0.59882	0.03321	0.90047	0.66455	0.00000

(4) Welch Tests

THE WELCH STATISTIC FOR METHOD 4 AND METHOD 2 IS: -1.236
WITH 9.710 DEGREES OF FREEDOM.
THE CRITICAL VALUE FOR REJECTING XBAR = YBAR IS: 0.248
THE CRITICAL VALUE FOR REJECTING XBAR > YBAR IS: 0.124
THE CRITICAL VALUE FOR REJECTING XBAR < YBAR IS: 0.876

THE WELCH STATISTIC FOR METHOD 4 AND METHOD 6 IS: -2.172
WITH 9.842 DEGREES OF FREEDOM.
THE CRITICAL VALUE FOR REJECTING XBAR = YBAR IS: 0.055
THE CRITICAL VALUE FOR REJECTING XBAR > YBAR IS: 0.028
THE CRITICAL VALUE FOR REJECTING XBAR < YBAR IS: 0.972

4. BACKGROUND QUESTIONNAIRE RESULTS

A. Coding of Background Areas

- GPA - Grade point averages
- SLPAVE - Average amount of sleep
- SLP1ST - Amount of sleep before the first test
- SLP2ND - Amount of sleep before the second test
- YOS - Years of schooling received
- TSLS - Time since last schooling
- NOBR - Number of books read in the last year

B. Data Analysis

(1) Grade Point Averages

	SAMPLE			RANGE	
	MEAN	VARIANCE	STD DEV	HIGH	LOW
METHOD 1	2.895	0.307	0.554	3.8	1.6
METHOD 2	2.925	0.306	0.553	3.5	1.8
METHOD 3	2.781	0.304	0.552	3.6	2.0
METHOD 4	2.794	0.427	0.653	4.0	2.0
METHOD 5	2.863	0.190	0.436	3.5	2.0
METHOD 6	2.620	0.348	0.590	3.0	1.2
METHOD 7	2.823	0.116	0.341	3.6	2.5

(2) Average Amount of Sleep

	SAMPLE			RANGE	
	MEAN	VARIANCE	STD DEV	HIGH	LOW
METHOD 1	5.950	0.803	0.896	7.0	4.0
METHOD 2	5.600	1.378	1.174	7.0	3.5
METHOD 3	5.125	0.696	0.835	6.0	4.0
METHOD 4	5.500	1.227	1.108	8.0	4.0
METHOD 5	6.100	1.656	1.287	8.0	3.5
METHOD 6	5.700	0.400	0.632	7.0	5.0
METHOD 7	5.230	0.696	0.834	6.5	4.0

(3) Amount of Sleep Before the First Test

	SAMPLE MEAN	SAMPLE VARIANCE	SAMPLE STD DEV	RANGE HIGH	RANGE LOW
METHOD 1	5.050	0.803	0.896	6.5	3.0
METHOD 2	5.900	3.044	1.745	8.5	3.5
METHOD 3	4.813	0.710	0.843	6.0	4.0
METHOD 4	4.917	1.992	1.412	7.0	2.0
METHOD 5	5.600	2.878	1.696	8.0	3.0
METHOD 6	5.050	0.969	0.985	6.5	3.0
METHOD 7	5.250	1.792	1.339	8.0	3.5

(4) Amount of Sleep Before the Second Test

	SAMPLE MEAN	SAMPLE VARIANCE	SAMPLE STD DEV	RANGE HIGH	RANGE LOW
METHOD 1	5.560	13.747	3.708	14.0	0.0
METHOD 2	7.150	4.169	2.042	10.0	4.0
METHOD 3	4.375	1.554	1.246	5.5	2.0
METHOD 4	4.958	0.521	0.722	6.0	4.0
METHOD 5	6.300	4.622	2.150	10.0	2.0
METHOD 6	6.150	4.003	2.001	9.0	3.5
METHOD 7	5.250	0.403	0.635	6.0	4.0

(5) Years of Schooling Received

	SAMPLE MEAN	SAMPLE VARIANCE	SAMPLE STD DEV	RANGE HIGH	RANGE LOW
METHOD 1	12.500	2.056	1.434	16.0	11.0
METHOD 2	13.100	4.100	2.025	16.0	11.0
METHOD 3	13.125	2.411	1.553	16.0	12.0
METHOD 4	12.250	0.795	0.892	14.0	10.5
METHOD 5	12.180	0.191	0.437	13.0	11.8
METHOD 6	12.250	0.181	0.425	13.0	12.0
METHOD 7	12.400	0.933	0.966	15.0	12.0

(6) Time Since Last Schooling

	SAMPLE MEAN	SAMPLE VARIANCE	SAMPLE STD DEV	RANGE HIGH	RANGE LOW
METHOD 1	1.340	0.846	0.920	3.1	0.5
METHOD 2	2.741	5.398	2.323	8.0	1.0
METHOD 3	1.999	2.412	1.553	4.1	0.5
METHOD 4	1.048	0.495	0.703	3.0	0.1
METHOD 5	2.450	4.178	2.044	7.0	0.5
METHOD 6	3.016	7.094	2.664	10.0	1.0
METHOD 7	1.550	1.318	1.148	4.1	0.1

(7) Number of Books Read in the Last Year

	SAMPLE			RANGE	
	MEAN	VARIANCE	STD DEV	HIGH	LOW
METHOD 1	43.900	5922.762	76.959	250.0	0.0
METHOD 2	28.700	6081.121	77.982	250.0	0.0
METHOD 3	7.875	177.554	13.325	40.0	0.0
METHOD 4	12.833	331.424	18.205	50.0	0.0
METHOD 5	49.600	15265.109	123.552	400.0	0.0
METHOD 6	4.000	23.556	4.853	15.0	0.0
METHOD 7	7.800	41.067	6.408	20.0	0.0

C. One-way ANOVA Results

Background Area	Test Statistic	Critical Level
GPA	0.348	.907
SLPAVE	1.190	.353
SLP1ST	0.849	.572
SLP2ND	2.007	.081
YOS	1.042	.448
TSLS	1.920	.092
NOBR	0.867	.560

LIST OF REFERENCES

1. Warren, M.W., *Training for Results - A Systems Approach to the Development of Human Resources in Industry*, pp. 70-74, 103, Addison-Wesley Publishing Company, 1969.

2. Special Devices Center Report 476-02-3, *Training by Television: A Study in Learning and Retention*, by R.T. Rock, Jr., J.S. Duva, and J.E. Murray, p. 23.

3. Fulmer, R., *Rate of Reading and Auding*, Qualifying Paper, Harvard University of Graduate Education, May 1976.

4. Rakes, T.A., *A Readability Analysis of Reading Materials Used in Adult Basic Education*, speech given at the annual convention of the International Reading Association, 17th, Detroit, Michigan, 10-13 May 1972.

5. Goodwin, J.W., and others, *Comparison of Comprehension Levels*, Human Factors class project, Naval Postgraduate School, Monterey, California, December 1985.

6. "Speech Compression Units Cut Training Time and Fatigue and Boost Learning," *TRAINING: The Magazine of Human Resources Development*, p. 17, January 1980.

7. "Cut Training Course Reviewing Time in Half," *T.H.E. Journal, Technological Horizons in Education*, v. 6-4, May 1979.

8. "Overcoming the Time Barrier Effectively," *T.H.E. Journal, Technological Horizons in Education*, v. 6-3, March 1979.

9. Challis, A.J., *The Effect of Fixed and Learner Selected Rates of Compressed Speech in an Audio-tutorial Learning Environment of the Achievement of College Level Students*, paper presented at the third conference of Rate-Controlled Speech, Louisville, Kentucky, 1975.

10. Sticht, T.G., *Learning by Listening in Relation to Aptitude, Reading, and Rate-Controlled Speech: Additional Studies*, paper presented at the third conference of Rate-Controlled Speech, Louisville, Kentucky, 1975.

11. Odiorne, G.S., *Training by Objectives: An Economic Approach to Management Training*, p. 183, The MacMillan Company, 1970.

12. Londoner, C.A., *A Readability Analysis of Randomly Selected Basic Education and Vocational Education Curriculum Materials Used at the Atterbury Job Corps Center as Measured by the Gunning Fog Index*, report for the Indiana University School of Education, Bloominton, Indiana, January 1967.

13. Davison, A., *Text Readability: Proceedings of the March 1980 Conference*, a collection of papers presented at the Text Readability Conference, University of Illinois, Urbana-Champaign, Illinois, August 1981.

14. Fruend, J.E. and Williams, F.J., *Elementary Business Statistics: The Modern Approach*, 4th ed., pp. 33, 579-82, Prentice-Hall Inc., 1982.

15. Navy Training Command, *Hull Maintenance Tech 3 & 2*, Government Printing Office, Washington, D.C., 1972.

16. Naval Education and Training Support Command, *Combustible Gas Indicator and Flame Safety Lamp*, Government Printing Office, Washington, D.C., 1979.

17. Naval Education and Training Support Command, *Compartmentation and Watertight Integrity*, Government Printing Office, Washington, D.C., 1979.

18. Naval Education and Training Support Command, *Desmoking and Emergency Ventilation Equipment Red Devil and Pneumatic Blower*, Government Printing Office, Washington, D.C., 1979.

19. Naval Education and Training Support Command, *Extinguishing Agents*, Government Printing Office, Washington, D.C., 1974.

20. Naval Education and Training Support Command, *Fire and Firefighting*, Government Printing Office, Washington, D.C., 1979.

21. Naval Education and Training Program Development Center, *Life Support Devices*, Government Printing Office, Washington, D.C., 1981.

22. Naval Education and Training Support Command, *Nozzles and Applicators*, Government Printing Office, Washington, D.C., 1974.

23. Naval Education and Training Support Command, *Portable FP-180 Water Proportioner*, Government Printing Office, Washington, D.C., 1974.

24. Training Analysis and Evaluation Group Technical Memorandum 83-2, *Readability Grade Levels of Selected Navy Technical School Curricula*, by J.W. Losa, J.A. Aagard, and J.P. Kincaid, PP.3, 11, February 1983.

25. U.S. Navy Recruit Training Command, *U.S. Navy CMI Recruit Reading Grade Level Analysis Report*, March 1986.

26. Training Analysis and Evaluation Group Technical Memorandum 82-5, *Readability Levels of Representative Navy Job Reading Materials for Nonrated Personnel*, by C.J. Hamel, J.A. Aagard, and J.P. Kincaid, p. 10, October 1982.

27. Dale, E. and Chall, J.S., "A Formula for Predicting Readability: Instructions," *Educational Research Bulletine*, v. 27, pp. 37-54, February 1948.

28. Winer, B.J., *Statistical Principles in Experimental Design*, 5th ed., p. 10, McGraw-Hill Book Co., 1962.

29. Larson, H.J., *Introduction to Probability Theory and Statistical Inference*, 3rd ed., pp. 444-461, 492-506, 527-541, John Wiley and Sons Inc., 1982.

30. Duncan, A.J., *Quality Control and Industrial Statistics*, 4th ed., pp. 620-31, Richard D. Irwin, Inc., 1974.

31. Gropper, R.L., *Comprehension of Narrative Passages by Fourth Grade Children as a Function of Listening Rate and Eleven Predictor Variables*, paper presented at the Third Conference on Rate-Controlled Speech, Louisville, Kentucky, 1975.

32. Winters, S.N., *Speed Listening: A Promising Path to Remediation of Reading Disabilities*, paper presented at the Third Conference on Rate-Controlled Speech, Louisville, Kentucky, 1975.

BIBLIOGRAPHY

McNinch, G.H., ed., *Comprehension: Process and Product. First Yearbook of the American Reading Forum*, a collection of papers delivered at the First American Reading Forum, Athens, Georgia, 1981.

Navy Personnel Research and Development Center Report TR-74-6, *Investigation of Rate-Controlled Speech for Training Applications*, by J.H. Steinemann and O.A. Larson, October 1973.

Smith, B.G., "Speed Reading Scores in Perspective," *Journal of Reading*, v. 19-2, November 1975.

Training Analysis and Evaluation Group Technical Memorandum 81-1, *Reading Grade Levels of Surface Warfare Officers School (SWOSCOL) Basic Curriculum Materials*, by J.A. Aagard, B.M. Pereyra, and J.P. Kincaid, February 1981.

U.S. Department of Health, Education, and Welfare, National Center for Educational Statistics, *Reading Rate and Comprehension: 1970-71 Assessment*, Government Printing Office, Washington, D.C., December 1972.

INITIAL DISTRIBUTION LIST

		No. Copies
1.	Defense Technical Information Center Cameron Station Alexandria, Virginia 22304-6145	2
2.	Library, Code 0142 Naval Postgraduate School Monterey, California 93943-5002	2
3.	LCDR Mike Lilienthal, Code 711 Naval Training Systems Center Naval Training Center Orlando, Florida 32813-7100	2
4.	LCDR Wright, Code 40 Service School Command Naval Training Center Orlando, Florida 32813-7100	1
5.	HTCM Hannan, Code 53 Damage Control School Recruit Training Command Naval Training Center Orlando, Florida 32813-7100	1
6.	AQCS Plocar, Code 30 Training Support Division Recruit Training Command Orlando, Florida 32813-7100	1
7.	Dr. Carl Williams, Code 24 Naval Aerospace Medical Research Laboratory Naval Air Station Pensacola, Florida 32507-5700	1
8.	Chief of Naval Research Office of the Chief of Naval Research Arlington, Virginia 22217-5000 ATTN: Library	1
9.	Dr. Stan Collyer, Code MAT-072 Office of Naval Technology 800 N. Quincy Street Arlington, Virginia 22217-5000	1
10.	Commanding Officer Air Force Office of Scientific Research Washington, D.C. 20319	1
11.	Research Director National Defense University Fort McNair Washington, D.C. 20319	1
12.	Chief of Naval Education and Training, Code L02 Naval Air Station Pensacola, Florida 32508-5700 ATTN: Dr. Robert Williams	1

13. LCDR Craig Knouse 1
1029 Frankland Road
Tampa, Florida 33629

14. LCDR Mark Mitchell, Code 55MI 1
Operations Analysis Department
Naval Postgraduate School
Monterey, California 93943-5000

15. Dr. Douglas Neil, Code 55NI 1
Operations Analysis Department
Naval Postgraduate School
Monterey, California 93943-5000

16. Dr. Glenn Lindsay, Code 55LS 1
Operations Analysis Department
Naval Postgraduate School
Monterey, California 93943-5000

17. LT Richard Phares 1
Operations Officer
USS Bronstein (FF1037)
FPO San Francisco, California 96661-1400

18. Mr. John Baskovich 3
211 Sandy Lane
Plano, Illinois 60545

19. Mr. Lester McKinney 1
1324 Belleaire Circle
Orlando, Florida 32804

20. Commanding Officer 1
Naval Education and Training
Program Development Center
Pensacola, Florida 32509-5000

21. Commanding Officer 1
Naval Research Laboratory
Washington, D.C. 20375

22. LCDR Chris Schnedar 1
2007 S. Penn
Roswell, New Mexico 88201

23. MAJ David Tyner 1
11 Maple Avenue
Avoca, New York 14809

24. Dr. Henry Smith 1
Command Instructional Systems Coordinator
Patrol Squadron Thirty One
Moffet Field, California 94035

Thesis
M57531 Michealson
c.1 A statistical analysis
determining effective and
efficient methods of
shipboard training.